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208

Y4.En2/3:99-FF

99th Congress
2d Session

COMMITTEE PRINT

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ORIGINAL

Mf-199

THE COMPETITIVENESS OF AMERICAN METAL MINING AND PROCESSING

A REPORT

PREPARED BY THE

CONGRESSIONAL RESEARCH SERVICE

FOR THE USE OF THE

SUBCOMMITTEE ON OVERSIGHT AND
INVESTIGATIONS

OF THE

COMMITTEE ON ENERGY AND COMMERCE

U.S. HOUSE OF REPRESENTATIVES

JULY 1986

U.S. GOVERNMENT PRINTING OFFICE
61-328 O WASHINGTON : 1986

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LETTER OF SUBMITTAL

June 16, 1986

Honorable John D. Dingell
Chairman, House Committee on
Energy and Commerce
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

As Chairman of the Subcommittee on Oversight and Investigations you requested that the Congressional Research Service undertake an examination of the competitiveness of the metal mining and processing sector of the United States. The resultant study would serve to crystallize the awareness of the 99th Congress of the difficulties that have overtaken this important segment of our basic industries in the first half of this decade.

Out of the many metallic elements used by our industrial society, our staff chose seven commodities which are the most important in value or tonnage to the United States. The monetary metals, gold and silver, were excluded because of their special roles as well as their relative growth and prosperity at this time.

John J. Schanz, Jr., Senior Specialist in Energy and Mineral Resources Policy, planned and coordinated the study in addition to contributing to a number of the sections. Dr. Schanz's colleagues were: John G. Ellis, Senior Research Assistant, who wrote the chapters on copper, lead, zinc, molybdenum, and iron ore; Pamela F. Woods, who wrote the first draft on aluminum while on detail with CRS from the International Trade Commission; Gary L. Guenther, Analyst in Industry Economics, who prepared the chapter on ferroalloys; Bernard A. Gelb, Analyst in Industry Economics, and Arlene E. Wilson, Specialist in International Trade and Finance, who authored the overarching discussion of the key problems of the metals industry; and Karen L. Hendrixson, Senior Research Assistant, who in addition to being co-author of several segments, was organizer of the up-dating of all the chapters over an extended period.

Sincerely,

Joseph E. Ross
Director

Enclosure

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U.S. House of Representatives
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of the
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Washington, DC 20515

June 17, 1986

LETTER OF TRANSMITTAL

To Members of Committee on Energy and Commerce:

As part of the Subcommittee's continuing oversight of the nation's "capital formation and industrial policy", I asked the Congressional Research Service (CRS) to undertake a wide-ranging and detailed study of the American metals mining and smelting industry. This report represents the fruit of that extensive effort by CRS. An interim report on the copper industry, at the time when it was under review by the International Trade Commission and the President, was transmitted to you on August 8, 1985.

This report provides the most comprehensive review currently available of the challenging situation facing the U.S. mining industry in the final decade and a half of the century. The Congressional Research Service has demonstrated decisively that the competitive pressures to be faced are severe and the problems complex. There is no single source of difficulty nor simple solution. In addition, the mix of difficulties varies from metal to metal. Nor can we expect that time will eventually provide the solution through a significant revival of demand. The report will provide Members with the many facets of the problems we hope will not only now be recognized, but solved.

On behalf of the Subcommittee, I wish to thank the Congressional Research Service project coordinator, John J. Schanz, Jr., and his colleagues, John G. Ellis, Bernard A. Gelb, Gary L. Guenther, Karen L. Hendrixson, Arlene E. Wilson, and Pamela F. Woods.

Sincerely,

John D. Dingell
Chairman
Subcommittee on
Oversight and Investigations

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THE COMPETITIVENESS OF AMERICAN METAL MINING AND PROCESSING

INTRODUCTION*

A simple, economic model of an exhaustible resource displays a finite supply being drawn upon at progressively higher costs until the remaining stock in the ground becomes too expensive to produce. As this happens, consumption patterns change, alternative resources begin to substitute for the commodity, and its use is gradually discontinued. A more complex model will introduce the impact of expanding knowledge and technology on the costs of finding and recovering the remaining resource supply, delaying the onset of higher price and extending the resource lifetime. Over the years these various characteristics of exhaustible resources have been explored at considerable length by various distinguished economists such as Ricardo, Hotelling, and Solow. Scarcity and Growth by Barnett and Morse when it appeared in 1963 was important in that it used historical data to demonstrate that despite progressive depletion of the original resource endowment of the United States for nearly a century (up to 1957) the real cost of extractive resources had been declining. Scarcity and Growth Reconsidered in 1979 presented arguments for either a continuation of the past decline or an actual or potential upward turn.

Imbedded in the past trend toward lower cost observed by Barnett and Morse were many contributory events - a better understanding of the genesis of ore deposits; the appearance of geophysical prospecting; the producers' high speed drills, improved explosives, and the caterpillar tread in surface mining equipment; the availability of low cost energy; the introduction of flotation to change low grade ores to higher grade concentrates; faster or cheaper transportation; electrified and automated equipment; and so on. Collectively, these innovations more than compensated for the expanding reliance on lower grade deposits which were frequently larger in size and sometimes more numerous. Historically the centers of U.S. metal mining have shifted or expanded in several directions. New, previously unexplored regions have been opened up. Mining and processing of different kinds of ore bodies or rock forms have become possible. More and more, mining involves a massive, earth-moving process, instead of an arduous pursuit of a slender, high grade vein plunging deep below the surface.

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*Prepared by John J. Schanz, Jr., Senior Specialist in Energy and Mineral Resources Policy, and Karen L. Hendrixson, Research Assistant, Office of Senior Specialists.

All of these events made it possible for the United States to draw down its original mineral resource endowment at competitive prices more intensively than any other nation in man's history. In this century for many of the major, large volume mineral commodities, the U.S. has been the leading world producer or among the top three. There are only a relatively small cluster of metals and minerals for which the United States does not appear to have a respectable opportunity to be a producer. Frequently this is a reflection of the fact that these commodities require modes of mineral deposition not common to the U.S. This group provides the prominent members of the group known as strategic and critical minerals that have received considerable attention over the years.

It is inescapable that at some point in the Nation's history, turning to new regions, new forms, larger deposits, and deeper occurrences can no longer compensate alone for the effects of depletion of our original stock. As technology has become more transferable, any initial domestic advantage based solely on quality of resource is eventually lost. New larger and cheaper deposits will continue to be found, but more and more this occurs in other parts of the world that have not been as intensively exploited. The U.S. position as a leading mineral producer has become increasingly dependent upon out-performing other producers with equal or superior deposits. Active consideration concerning some form of assistance, or subsidy, to the domestic U.S. mining sector in order for it to remain a world leader also begins to appear. The former response depends upon the vitality of the private firm for success. The latter, however, requires a specific policy decision to be made by the Federal Government that it is in the national interest to preserve all or part of the mining sector despite its decline in competitiveness. In the absence of either of these, and there are a number of historical precedents for this to occur, the U.S. can be expected, progressively over time, to become more import-dependent for resources. This would require adjusting to different economic circumstances than we have been accustomed to for over 100 years.

It is not suggested that the United States will suddenly move from a highly self-reliant nation to a have-not. There are many mineral commodities - coal, sand and gravel, clays, and so forth, which we need and produce in large tonnages. Rather, an awareness is urged that a more subtle shift may now be occurring--a gradual deterioration of competitiveness mineral-by-mineral. This study examines to what extent this has begun for several important metals. The implications that flow from these observations are then identified, particularly with respect to where in-depth analysis would be useful.

Seven of the more important U.S. metals industries have been chosen to show how the United States may be faring either relatively well or poorly in maintaining its position in world metal trade. In each of these, the objective is to use the commodity to isolate and describe the various elements and combinations of factors that generate advantages or disadvantages for the U.S. The more important problems identified are then discussed separately to illuminate their nature and to discuss what responses are available to the U.S. either by the industry itself or by government action. Unavoidably, certain key questions concerning security appear. How essential are the mineral industries and is there some yet-to-be-defined "peril point" below which the U.S. industrial and economic integrity is threatened?

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I. THE FUTURE DEMAND FOR METALS*

One of the classic laws of economics is the "acceleration principle" of business cycles, which holds that the rapid growth of net investment (additions to the stock of capital) will only occur when the national income expands. In simpler terms, one may observe an increase in sales of consumer goods which is accompanied by a growth several times greater in the net sales of machine tools needed to produce these additional consumer goods. Because the large increase in machinery needed to produce these goods entails a large increase in the quantity of metals used, the mineral industries are among the industrial groups that prosper on the upside of the business cycle. Unfortunately, they suffer the consequence of little or no investment in capital goods in periods of economic downturn.

The improvement in the U.S. economy beginning in 1982, as signalled by an increase in the growth rate of real Gross National Product (GNP), seemed to portend better times ahead for the domestic metals producers. However, uncharacteristically this did not occur, and as the economic growth rate seems to be slowing in 1986 it appears that this particular business cycle has not brought better market conditions to the metals sector. The obvious question is why hasn't the domestic metals industry behaved according to the time-honored acceleration principle?

As will be discussed in greater detail in subsequent chapters, one of the factors at work has been that the United States is no longer the world's leading producer of most metals. It now functions within the framework of the total world market rather than in isolation or as a dominant force. The U.S. metals producer today is affected not only by events in the United States economy but in the world economy as well.

This transition by the United States from a position of dominance among world metal producers is not likely to be reversed. To glimpse how much the U.S. share of the world's metal output might continue to fall, projections by the U.S. Bureau of Mines for four metals are combined with World Bank growth estimates to arrive at projected U.S. and world production for the year 2000 (see table I:1). For

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*Prepared by John J. Schanz, Jr. Senior Specialist in Energy and Mineral Resources Policy, and Karen L. Hendrixson, Research Assistant, Office of Senior Specialists.

Table I:1. U.S. and World Production[a], Selected Metals
(thousand metric tons, except as noted)

COPPER

	1975	1980	1983	2000[b]
U.S.	1,282	1,181	1,038	1,400
World[c]	6,962	7,630	8,044	10,361
U.S. Share of World Production (%)	18.4	15.5	12.9	13.5

IRON ORE[d]

	1975	1980	1983	2000[b]
U.S.	78.9	69.6	37.6	44.6
World[c]	877.6	873.6	729.6	821.5
U.S. Share of World Production (%)	9.0	8.0	5.1	5.4

LEAD

	1975	1980	1983	2000
U.S.	564	551	449	620
World[c]	3,438	3,520	3,350	4,388
U.S. Share of World Production (%)	16.4	15.7	13.4	14.1

ZINC

	1975	1980	1983	2000
U.S.	426	317	275	700
World[c]	5,562	5,745	6,246	9,042
U.S. Share of World Production (%)	7.7	5.5	4.4	7.7

Notes

(a) Mine production.

(b) U.S. projected production data are U.S. Bureau of Mines estimates. World projected production data are extrapolated from 1983 world production figures, using World Bank projected growth rates per annum from 1979/81-95 (for ore and metals), through the year 2000.

(c) Inclusive of U.S.

(d) Million long tons of ore.

Sources: U.S. Bureau of Mines. Mineral Commodity Summaries. Various years.
U.S. Bureau of Mines. Mineral Facts and Problems. Preprints from Bulletin 675. 1985 ed.
World Bank. The Outlook for Primary Commodities, 1984-95. Staff Commodity Working Papers, No. 11. 1984. p. 56.

copper, iron ore, and lead, the United States share of world output is estimated to continue to decline. For zinc, the U.S. share has dropped but may recover to a point equivalent to that of 1975. Based on these projections of possible future production, the conjunction of a highly competitive international supply situation with the declining quality of domestic mineral resources, suggests that the diminished U.S. role as a metals producer is a chronic condition, rather than just an acute or transient one.

For a variety of reasons, the economic revival experienced by the United States in the early 1980s was not shared equally by the other major industrial nations of the world. As a result, the demand--and therefore the prices--for metal commodities in international markets did not strengthen. Prices remained close to the levels prevailing in the late 1970s, and the usual producer reward of more units sold at a higher price per unit in periods of economic expansion did not occur.

Morever, as world production capacity exceeded world demand, foreign producers were eager to find whatever outlets they could in supplying the robust U.S. economy. Metal shipments, attractively priced, found buyers in U.S. markets even though metal demand was not actually expanding along with the economy. As a consequence, some U.S. metal producers found their sales were actually decreasing in a time of business expansion. As long as the economic policies of the world industrial nations do not trigger greater economic growth and thus reduce unemployment levels, it is to be anticipated that U.S. metal producers will continue to encounter rigorous price competition both at home and abroad from foreign producers.

These factors account partially for the lack of upward movement in the prices received by metal suppliers in the U.S. market when the domestic economy was actually expanding. But they do not explain why the demand for metals in the U.S. did not display the typical growth in the quantity of metal consumed both for durable and consumer goods. It is now becoming more apparent that the intensity-of-use of metals (metal consumption per unit of Gross Domestic Product, or GDP), is likely to stagnate or even decline in general as an industrial nation matures. This suggests that forecasts of U.S. requirements for metals that assume a continuation of the past positive linkage between GDP and metal use will tend to overstate the future consumption of metals. In actuality, the United States may need less metal to support a given level of economic activity than in the past.

This does not deny that there is a considerable need for metals if an economy is to change its structure from an agrarian type to an industrial one. This expanded use of metals continues as the consumption of an affluent industrial nation, such as the United States in its recent past, becomes metal "intensive" through purchases of cars, homes, and equipment, utensils, and the like. But at some point a structural shift occurs as this consumer behavior pattern alters. It is now suspected that intensity-of-use can diminish as the bulk of the population reaches a fairly high level of personal income and savings and begins to merely replace what it already possesses, rather than expanding its net consumption per capita of additional metal-intensive goods. Consequently, capital growth and net investment in industrial development lags even in better economic periods. In addition, the recent higher cost of energy and capital has encouraged a reduction of the amount of metals used per product unit, as exemplified by the downsizing of automobiles.

These emerging trends have now been under observation for over a decade and further research on the data and hypotheses is still required to confirm and better understand what is happening. However, the sample of consumption trends in table I:2 illustrates this type of shift in metal consumptive behavior. The 1984 study by the World Bank suggests that this is not a temporary trend. The bank expects that in the next decade as well metal consumption in the developed nations will not regain the growth rates attained in 1950-74. 1/

Table I:2. Developed Market Economies' Metal Consumption Trend vs. GDP Growth Rates (percent)

	Rate of Growth in Metal Consumption (%)	Rate of Growth in World GDP (%)
Aluminum		
1960-73	9.3	4.9
1973-79	3.2	2.5
Copper		
1960-73	4.6	4.9
1973-79	1.5	2.5
Lead		
1960-73	4.6	4.9
1973-79	1.1	2.5
Zinc		
1960-73	5.4	4.9
1973-79	-0.6	2.5

Source: Energy, Mines, and Resources Canada. Mineral Policy: A Discussion Paper. Report MP 81-1E. December 1981. p. 38.

1/ Projected per annum growth rate of apparent consumption for 1979/81-95 for aluminum is 2.1 percent; for copper, 1.4 percent. Duncan, Ronald C. (ed.). The Outlook for Primary Commodities, 1984 to 1995. World Bank Staff Commodity Working Papers, No. 11. Washington, D.C. 1984. pp. 44-45.

Projections based on past experience become suspect if we believe that the intensity-of-use of metals in the western world has and will remain fundamentally changed from the pre-1975 experience. In addition to conjecturing that this reflects a more mature stage of economic development in the U.S., or some structural change in the nation's mix of what it needs or can sell to other nations, there is a complex set of other factors that may be at work in some unknown combination. One possibility is that we are beginning a shift to a new mix of modern materials--such as exotic alloys, new ceramic products, or composites. Or perhaps new technologies that rely on miniaturization and electronic components have changed our needs. If these trends are pervasive then copper, lead, and zinc may become the modern day "buggy whip" industries destined to become progressively less important in the economy.

These possible trends in the maturation of metals demand are critically important in that they suggest that our immediate past expectations for future world demand for metals, which is unavoidably linked to past experience, may now have to be viewed as overstating rather than understating the future. Moreover, the demand for metals in the United States in particular, which would be especially vulnerable to such changes may be quite difficult to estimate with confidence.

Despite some reservations as to how well analysts can capture these new demand factors, it is instructive to view U.S. demand trends versus those of the world. Table I:3 displays projections by the U.S. Bureau of Mines of U.S. and world demand for five basic metals in the year 2000 compared to 1983 demand levels. It is apparent that future growth rates of demand in the United States for these major metal products will not be rapid. Except for zinc, demand is projected to grow much more rapidly in the rest of the world than in the United States. This increasing world demand results, in large part, from the growing populations and modernizing economies of the developing nations. In contrast, the stable U.S. population and mature economy will constrain future demand levels at a projected high of 2.7 percent growth per annum for aluminum, to only negligible growth for lead. It should be noted that even projected future world levels of demand, however, are expected to fall below those rates of consumption achieved achieved from 1950 to 1974 in western industrial countries, as illustrated in table I:2.

Readily accessible, current, and comparable forecasts from other recognized authorities are not available to contrast with the Bureau of Mines' outlook. While a number of consulting firms do make such studies, these are proprietary in nature. In any case, varying assumptions and definitions make it difficult to arrive at a consensus view. However, from those studies that are available, the lesser growth in U.S. domestic markets for metals and reservations about the rate of growth in the world seems to be accepted generally.

Table I:3. U.S. and World Primary Metal Demand, 1983 AND 2000[a]
(thousand metric tons)[b]

	Aluminum[c]			Copper			Iron Ore		
	1983	2000	Ave. annual rate of growth (%)	1983	2000	Ave. annual rate of growth (%)	1983	2000	Ave. annual rate of growth (%)
UNITED STATES	4,622	7,260	2.7	1,565	2,100	1.7	40,642	54,431	1.7
REST OF WORLD	11,878	23,540	4.1	6,200	10,000	2.9	382,288	580,598	2.5

Lead			Molybdenum			Zinc[c]		
1983	2000	Ave. annual rate of growth (%)	1983	2000	Ave. annual rate of growth (%)	1983	2000	Ave. annual rate of growth (%)
689	700	0.0	20	32	0.8	929	1,250	1.8
2,550	3,150	1.3	49[d]	86	3.3	5,450	7,500	1.9

Notes:
(a) Using "probable" estimates on a forecast range of high to low.
(b) Tons of zinc content and contained iron.
(c) Includes non-metal primary demand.
(d) Bureau of Mines estimate.

Source: U.S. Department of the Interior. Bureau of Mines. Preprints from Bulletin 675, Mineral Facts and Problems. 1985 edition.

If U.S. metal production has become and will remain higher cost than that of many of its overseas competitors, then this view of the restrained growth in demand does not offer much hope that a revived world market might of itself be sufficient to extricate the domestic metals mining and processing industry from its current travail. The problems of this sector and possible solutions must be examined in another context. For this purpose, the situation being faced by the individual metals industries is examined in detail in the following chapters.

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II. COPPER*

A. Introduction

One would expect that the prime candidate for this initial section in the examination of the strengths and weaknesses of the U.S. metals industry would be steel. It is not, for several reasons. One, the problems of the steel industry have been quite visible to the Congress and the public for a number of years. This has brought it the lion's share of attention, and it is the subject of numerous studies, including some produced by the Congressional Research Service. 1/ Two, it has been customary among mineral commodity analysts to recognize that the size and nature of the steel industry sets it apart from the smaller industries that produce ferroalloys and the non-ferrous metals. Finally, many of the problems of steel are found in the downstream milling sector and the manufacture of semi-fabricated products, rather than in the initial mining and refining. However, the iron ore mining segment of the steel industry which is geographically and physically separated from the production of iron and steel is often overlooked. The particular problems of iron ore mining will be included here so that a comprehensive view of U.S. major metals mining is presented.

Second to steel in importance among the U.S. metals industries is copper, and it provides an ideal starting point for this study. Copper is examined in greatest detail because it provides an excellent exposure to the entire gamut of circumstances now facing the firms that mine and refine ores. In addition, in 1984 copper entered the limelight when the U.S. International Trade Commission recommended that the President take steps to protect this industry from the damage being inflicted by overseas competition. Thus, copper displays an industry simultaneously experiencing a decline in the quality of domestic resources, a loss of other advantages that had kept the sector highly productive and competitive for many years, and the

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1/ See Grinnell, David. Outlook for the U.S. Steel Industry: A Study by End-Use Sector. CRS Report 84-77S. June 18, 1984. 75 p. Cantor, David J. America's Steel Industry: Modernizing to Compete. CRS Report 84-786F. April 23, 1984. 27 p.

*Prepared by John G. Ellis, Research Assistant, Office of Senior Specialists growing exposure of U.S. producers to an international market where many of the players have different sources of capital, marketing strategies, and national goals than had been characteristic of the family of copper producers in the past.

B. Market Share and Current Economic Conditions

Both in terms of employment and of total contribution to Gross National Product, copper is the largest of the domestic nonferrous minerals industries. Indeed, the United States still has the world's greatest potential for the production of copper, both in terms of installed capacity and is second to Chile in copper metal resources. However, when actual utilization of capacity dropped to approximately 65 percent in 1982 and 1983, the United States was surpassed for the first time in more than a century as the world's largest supplier. By increasing its production to 1.2 million metric tons, Chile took over that position in 1982. In 1983 and 1984, U.S. mines produced just over one million metric tons of contained copper, well below the 1.5 million ton level that had been achievable throughout the last decade.

The U.S. copper industry has in recent years also begun to show signs of competitive weakness in the international market. Domestic mine output, which reached its maximum level in the late 1960s, fell to below 60 percent of total domestic supply (in terms of metal content) in the 1970s and early 1980s (see table II:1). Despite continued improvements in productivity, negative factors such as comparatively lower ore grades, increased stripping ratios and relatively higher labor costs seem to suggest that this downward trend could continue.

Table II:1. Domestic Copper Producers' Contribution to Total Available Supply[a], 1956-60, 1966-70, and 1976-80 (percent, in terms of copper content)

	1956-60	1966-70	1976-80
Domestic Ores and Concentrates	52	61	57
Domestic Smelter Products	66	60	56
Domestic Refinery Products	69	67	62
Domestic Secondary Products	22	23	22

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[a] "Total available supply" is defined as U.S. production plus imports. U.S. exports are included in supply on the assumption that they would be available in the U.S. if demanded.

Source: U.S. Bureau of Mines. Minerals Yearbook [various issues].

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Copper smelters and refineries have experienced even greater difficulties. The classic pattern of industrialization is for a country to progress from being an exporter of raw materials to processing at home more and more domestic and foreign primary materials into products of higher value. Eventually, it becomes a net importer of raw materials and begins to emphasize the production of processed materials and manufactures.

The various segments of the U.S. copper industry, however, have for some time followed a somewhat unorthodox path for an established, industrialized economy. Domestic copper smelting and refining operations, which would presumably enjoy an advantage over developing country competitors under the standard profile of industrial development, fared less well than domestic mining operations. While the U.S. copper processing industry's share of total domestic supply declined for three decades (see table II:1), the U.S. became a net exporter of ores and concentrates. However, this atypical behavior should disappear as the result of domestic mine closings that began in 1982.

Domestic copper refinery production has declined less rapidly than smelter production, with the result that net import reliance on smelted products (e.g., copper mattes and blister) has more than quadrupled between the 1956-60 and the 1976-80 periods. Even with the additional foreign sources of raw materials, however, domestic copper refineries have also been unable to maintain the previous U.S. position as a net exporter of cathode copper. In fact, after dropping during the 1982 recession, net refined imports surged to nearly 18 and 17 percent, respectively, of total available domestic supply in 1983 and 1984. If recent trends continue, it has been estimated that imports could permanently take as much as 30 to 40 percent of the refined market for primary metal by the early 1990s. 2/

Copper Prices, Profits, and Production Rates During the Recession

Probably no integrated U.S. copper operation was able to break even on its operating costs at the average 1982 and 1983 international prices of $.67 and $.70 per pound of copper. As a result, the domestic industry experienced record financial losses, amounting to $1.15 billion in 1982, and $605 million in 1983. Losses for 1984 were an estimated $550 million. 3/

Drastic cutbacks in U.S. copper production resulted from this traumatic financial situation. By 1984, 565,000 metric tons of mine

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2/ Confidential source. Capital Metals Forum. August 14, 1982.

3/ U.S. Bureau of Mines. Minerals and Materials. Washington. February/March, 1985. p. 10.

capacity were completely shut down. This is a drop of 25 percent in the industry's estimated capacity in 1980. In addition, another 305,000 tons of capacity were not being utilized at mines operating on a restricted basis. Employment suffered accordingly, with the average number of employees in the mining and in the smelting and refining of copper in 1984 down by 49 percent from 1981 levels. 4/

Although most foreign producers were also experiencing financial difficulties in the depressed markets of 1982 and 1983, far fewer production cutbacks and less unemployment resulted. 5/ Non-U.S. world production in the last few years remained almost constant, while domestic mine output was being reduced by 26 percent in 1982 and by a further nine percent in 1983, rising only slightly in 1984. 6/

Many explanations have been offered for the uneven international producer response to the depressed conditions that continue to be experienced in world markets. In the United States, it has been argued with increasing frequency that the public sector's ownership of most Third World production capacity is the main reason why those countries' supply decisions often contravene private sector standards of rational economic behavior. 7/ According to this thesis, developing country copper production is not reduced during an economic recession because of foreign governments' desire to protect employment and export earnings. Many believe that while market prices remain at historically low levels, production is being sustained through the help of large public subsidies.

Some foreign producers maintain, on the other hand, that the concentration of production cutbacks in the United States reflects the domestic industry's weak cost competitiveness relative to most foreign production. In economic terms, they argue, it is reasonable for lower cost foreign operators to expect marginally economic U.S. suppliers to absorb a larger share of the reduction in consumption experienced during business cycle fluctuations. If the market is functioning efficiently, more competitive foreign production should only experience a decline after most of the marginally profitable output has

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4/ U.S. Department of the Interior. Bureau of Mines. Mineral Commodity Summaries 1985. Washington: U.S. General Printing Office. p. 40.

5/ Mining Annual Review, 1984. Mining Journal, Ltd. 1984. p. 33.

6/ Mineral Commodity Summaries 1985. pp. 40-41.

7/ See for example, DeConcini, Dennis. Remarks in the Senate. Congressional Record, Daily Edition. May 22, 1984. p. S6252.

been shut down. It is contended that much of the marginal capacity is now located in the United States. 8/

Production Cost Comparisons

Whether or not a significant portion of U.S. copper capacity is marginally economic and, more importantly, whether it might remain so, is a highly contentious issue. To determine this, the costs of copper production need to be examined both in total and as individual components. Not only might this disclose whether U.S. costs tend to be relatively high, but it also offers an opportunity to judge how much needs to be done to enhance U.S. competitiveness.*

Unfortunately, industrial cost comparisons are always hampered by the quantity and vintage of the data available. Much of the analysis that follows is based on cost data provided by the Minerals Availability Program at the U.S. Bureau of Mines. These data indicate that in 1981, which coincides with the onset of acute U.S. difficulty, that the average total costs of producing copper in the United States were 23 percent above the averages for all foreign copper industries in market economy countries. The differences in average break-even costs (i.e., "net operating costs"), which exclude fixed financing charges and an arbitrarily assigned 15 percent rate of return, were even greater (26 percent). Since the costs of temporary shutdowns are very high in the copper industry, operations have often been continued on an unprofitable basis during periods of market downturn. Consequently, as long as cash flow permits, the break-even point has more relevance for short-run production decisions than do total production costs (see table II:2).

Operating costs, of course, may vary considerably among individual operations, both within the United States and between the U.S. and other countries. Thus, despite its apparent average cost disadvantage in 1981, about one-fifth of the U.S. industry's capacity could have been profitable even at a price equal to the average foreign break-even cost of production ($.73 in 1981, or $.81 in 1983 dollars). On the other hand, it is important to note that several large Canadian and Chilean operations appear to have been capable of sustaining a return on investment at prices below the break-even point of the lowest cost U.S. producers ($.53 in 1981, or $.59 in 1983) (see table II:3).

8/ Williams and Thorman, counsel. Testimony on behalf of the Canadian suppliers before the U.S. International Trade Commission. Investigation TA-201-52, Unwrought Copper, May 16, 1984.

*The cost comparisons in this report concentrate on Canada, Chile, and Peru. These three countries account for approximately 70 percent of all imports of refined copper into the U.S.

Inflation and Exchange Rate Fluctuations

The cost comparisons in tables II:2 and II:3 reflect the economic structure of production in various copper producing countries in 1981. Because individual industries experience different rates of reserves depletion and productivity growth, these relationships have been changing between 1981 and 1985. In addition, short-term competitiveness is constantly being altered by monetary phenomena such as inflation and exchange rate movements. It is important to be aware of and understand these latter phenomena.

Table II:2. Estimated Weighted Average Production Costs for Producing Mines[a] (1981 dollars per pound of contained copper)

	U.S.	Canada	Chile	Peru	All Foreign
Mine and Mill	.64	.69	.52	.51	.53
Smelter/Refinery	.37	.52	.22	.31	.30
Operating Cost	1.01	1.20	.73	.82	.82
Taxes	.05	.05	.06	.12	.11
Byproduct Credits	- .15	- .62	-.10	- .06	-.21
Net Operating Cost	.92	.68	.68	.88	.73
Total Cost (f.o.b. refinery)	1.07	.85	.78	1.12	.87

[a] Totals may vary from items due to rounding.

Source: U.S. Bureau of Mines. Calculated from data in Copper Availability-Market Economy Countries, IC 8930. 1983.

Table II:3. Estimated Net Production Cost Ranges for Producing Copper Mines in Selected Countries (average 1981 dollars per pound of refined copper)

Country	Number of Mines	Highest Cost	Lowest Cost (a)	Average Cost
U.S.	24	$1.41	$ .53	$.92
Canada	20	1.65	-1.08	.68
Chile	7	1.10	.38	.68
Peru	4	1.23	.80	.88

(a) A negative net cost indicates that byproduct or co-product credits exceed operating costs.

Source: U.S. Bureau of Mines. Minerals Availability Program. Unpublished data.

The U.S. dollar, after depreciating by more than 20 percent between 1976 and 1978 against the currencies of ten major industrial countries, rose by more than 50 percent against the same currencies between mid-1980 and 1983. This appreciation, which had many causes not related to trade competitiveness, made U.S. exports much more expensive abroad and imports cheaper. Thus it has now been identified as a major cause of the nation's very large international trade deficit.

During the early 1980s the dollar rose even more rapidly against the currencies of some of the most important foreign copper-producing countries. Their currency depreciation, however, reflected rampant inflation in those countries. The higher local currency value of dollars received for exports, stemming from the appreciation of the dollar vis-a-vis the Chilean and Peruvian currencies, was countered by a rapid increase in local currency costs of copper mining and milling in those countries.

Monetary conditions in Chile and Peru were particularly tumultous. Consumer prices in Chile tripled in the four years from 1977 to 1981 and, despite a determined anti-inflation program, went up by another 36 percent from 1981 to 1983 (see table II:4). The exchange rate fell (that is, Chilean pesos per dollar went up) by considerably less in the former period because of an attempt to stabilize the peso in the 1979 to 1981 period, as part of the ant-iinflation campaign. Because the exchange rate's decline failed to keep pace with inflation during this period, Chilean consumer prices (and presumably production costs) when converted to dollars rose considerably faster than those in the United States. As a result, the profitability of Chilean exports, including copper, was squeezed during this period.

After the exchange rate stabilization failed, the Chilean peso depreciated by more than 100 percent from 1981 to 1983, and Chilean prices and costs fell sharply in terms of dollars, restoring that country's competitiveness and profitability in international trade. It is reported, for example, that the net operating costs of the Corporacion Nacional del Cobre de Chile (Codelco-Chile) expressed in dollars declined by more than 25 percent in 1982 as a result of the peso's depreciation in that year. 9/ The decline continued into 1983 contributing to the company's ability to remain profitable, despite the record low copper prices in 1982 and 1983.

To the extent that foreign producers' costs were incurred in dollars, however, local inflation and exchange rate changes did not affect competitiveness vis-a-vis the U.S. This is an important

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9/ High Grade Codelco Shows the Way in 1982 and Keeps Up the Pressure. Mining Journal. April 1, 1983. p. 215.

Table II:4. Indexes of the Price of Copper and of Consumer Prices (CPI) Converted to U.S. Dollars in Copper-Producing Countries, 1977-83

(1981 = 100)

			Canada			Chile			Peru		
Year	Price of Copper	U.S. CPI	CPI	Exchange Rate 1/	$CPI	CPI	Exchange Rate 1/	$CPI	CPI	Exchange Rate 1/	$CPI 2/
1977	75	67	68	92	74	33	55	60	14	26	54
1978	78	72	74	100	74	46	81	57	21	39	54
1979	113	80	81	98	83	62	96	65	36	49	73
1980	125	91	89	101	88	84	100	84	57	67	85
1981	100	100	100	100	100	100	100	100	100	100	100
1982	85	106	111	104	107	110	130	84	164	196	84
1983	88	109	117	104	113	136	203	67	246	313	79

1/ Local currency per U.S. dollar. A rising index means depreciation of the local currency and appreciation of the dollar.

2/ The index of foreign consumer prices converted to dollars is obtained by dividing the foreign CPI by the exchange rate in local currency per U.S. dollar and multiplying by 100.

Source of Data: International Monetary Fund, International Financial Statistics and the U.S. Bureau of Mines.

consideration in Third World countries where, because the industrial base is not extensive, many capital goods must be imported. More than half of Codelco-Chile's recent plant and equipment purchases, for example, have come from foreign suppliers who require payment in dollars. 10/ This share was probably much larger for Peruvian copper exporters. Like U.S. producers' costs, such expenditures might be expected to track inflation in the U.S. economy and, as a result, be unaffected by the depreciation of the peso or the sol against the dollar. In such cases, profitability and competitiveness are determined by changes in costs relative to changes in each producers' received price of copper.

It appears that between 1977 and 1981 the combined effects of inflation and exchange rate adjustments tended to improve U.S. cost competitiveness. In that period, the inflation rates in Chile and Peru in particular exceeded the depreciation of those countries' currencies vis-a-vis the U.S. dollar, so that their dollar denominated internal inflation rates (and presumably costs) tended to advance more rapidly than U.S. consumer prices (and presumably costs). Since 1981, however, most of those gains have been lost. In 1982 and 1983, the depreciation of the Chilean and Peruvian currencies was much more rapid than those countries' inflation rates. As a result, peso- and sol-denominated production costs tended to fall relative to the U.S. and Canadian levels.

In addition, prices in recent years improved more for some foreign producers than for U.S. producers. Copper sold at the London Metal Exchange (LME), the other world market center for copper, is priced in pounds sterling. Differential movements in exchange rates, the dollar's appreciation, and Peruvian and Chilean depreciations caused pound sterling denominated prices for copper sold on the LME to rise substantially in terms of some currencies. Thus, in 1983 and 1984, the London price expressed in Chilean pesos rose 66 percent and 8 percent respectively. Expressed in Peruvian sols, the prices rose 151 and 84 percent in those same years. By contrast, in U.S. dollars the LME price rose only 8 percent in 1983, and decreased 13 pecent in 1984. 11/ Of course, these gains would have been offset by the fact that the same currency movements also meant that foreign producer's costs when incurred in dollars also rose.

To summarize, monetary events have affected significantly the U.S. copper industry's cost position over time apart from any real changes in the costs of mining and smelting ores and concentrates. As the difficulties of the copper industry began to receive greater

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10/ The Economist Intelligence Unit, Ltd. Quarterly Economic Review of Chile - 4th Quarter, 1982. p. 15.

11/ LME average settlement price for higher grade cathodes. Mining Annual review--1985. Mining Journal (London). 1985. p. 53.

attention in 1984 and on into 1985, judging the efficacy of the various remedies proposed is made much more complex both by the nature of these monetary developments but also by the considerable uncertainty as to when and how much these circumstances may change in the future. By early 1986 the key question became how much the weaker dollar and any changes in the inflation rate in various countries might improve the domestic copper industry's situation. For those who viewed it as a panacea, they would have an opportunity to test their hypothesis.

C. The Copper Mining and Milling Industry

In order to compete with the major foreign producers, the domestic copper mining industry must overcome the initial disadvantage of dependence on lower average ore grades. Although all the major operations in the U.S., Chile, and Peru work geologically similar porphyry deposits, the average copper content of the latter two countries' currently produced ore is 1.02 percent and 0.79 percent respectively, compared to the U.S. average of 0.67 percent. 12/ To obtain the same amount of copper, then, U.S. producers have been mining and milling one and one-half tons of ore for every one ton extracted by the Chilean industry.

Because some low grade operations are much more efficient than their competitors, this does not in itself dictate a U.S. cost disadvantage. The competitive benefits that Chilean producers derive from their high grade ore bodies, for example, is somewhat diminished by their heavier reliance on underground mining operations, where productivity is generally lower than in surface operations. Such differences in efficiency, on the other hand, are not as evident in copper milling operations, where the availability of high grade ore translates more directly into lower production costs. In any event, the ability of a copper producer using low grade ore to maintain its cost-competitiveness depends on its ability to maintain higher levels of energy, labor and capital productivity throughout its entire operation.

Energy Costs

Energy is consumed with increasing intensity as the ore grade of copper mining operations declines. U.S. Bureau of Mines' data show that the average U.S. operation, with an ore grade that is one-third

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12/ Rosenkranz, R. D., et.al. Copper Availability - Market Economy Countries, A Minerals Availability Program Appraisal. IC 8930. U.S. Bureau of Mines. U.S. Department of the Interior. 1983. p. 6.

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less than the Chilean average, uses approximately 50 percent more energy to extract each pound of copper metal from its ore. 13/

Relative abundance of domestic supplies and various government regulatory policies have, in the past, kept U.S. energy prices below the levels prevailing in some of the more import-dependent developing countries. As a result, the greater energy-intensiveness of domestic copper production probably did not constitute a significant competitive disadvantage in the 1960s and 1970s.

As U.S. markets have been increasingly influenced by changing prices in international energy markets, however, this balance between greater consumption and lower unit costs has probably eroded. Between 1977 and 1981, typical electricity bills for large, industrial consumers in the southwestern United States rose, in real terms, by over 15 percent. 14/ Electricity accounts for about 60 percent of the energy consumed in domestic copper mining and milling operations. 15/ Between 1978 and 1983, domestic prices for industrial users of natural gas, the second largest source of energy, nearly tripled. 16/

At the same time, some foreign producers have been able to reduce their energy costs by switching to cheaper, locally available sources of supply. This has been particularly true for Chile, which has recently increased its production of coal-fired electricity in order to replace petroleum imports. The availability of additional hydroelectric capacity has also contributed to the reduction of electricity costs, which probably now average 20 to 30 percent below average U.S. costs. 17/

Labor and Productivity

Labor costs are the largest single component of the domestic copper industry's total operating costs, accounting for 35 to 40 percent

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13/ Sousa, Louis J. The U.S. Copper Industry: Problems, Issues, and Outlook. U.S. Bureau of Mines. U.S. Department of the Interior. 1981. p. 35.

14/ Energy Information Agency. Typical Electric Bills. U.S. Department of Energy. January 1, 1981. p. 263.

15/ Gelb, Bernard A. and Jeffrey Pliskin. Energy Use in Mining: Patterns and Prospects. Cambridge, Ballinger Publishing Company. 1979. p. 62.

16/ Energy Information Agency. Natural Gas Monthly - March 1984. U.S. Department of Energy. 1984. p. 29.

17/ Hunt, Brook. Chile, Outlook for Copper Production to 1990, unpublished. September 8, 1980. p. 23, 40.

of the final price of refined copper. In 1981, the last year for which industry-wide data are available, average total compensation (wages and benefits) per employee amounted to over $34,000 per year, over half again as much as the equivalent earnings for U.S. manufacturing industries as a whole. Between 1978 and 1981, increases in U.S. copper workers' average total compensation exceeded inflation by 2.5 percent per year. While these increases have probably slowed and reversed since 1981, the lack of current statistics on benefits and other non-wage compensation make it difficult to determine the precise magnitude of such changes. Straight-time wages in copper mining, however, increased by 5.8 percent in 1982 and by 4.5 percent in 1983. In 1982, this rate was 0.3 percent below and, in 1983, 1.3 percent above the year-to-year growth in U.S. consumer prices. 18/

The contrast between U.S. and foreign mining wages has been and continues to be even more stark, particularly as regards the Latin American industries. In 1978, on the basis of the exchange rate, the average Chilean and Peruvian copper miner earned the wage equivalent of only $1.35 and $1.61 respectively per hour, less than one-fifth the $8.46 wage of their U.S. counterparts. 19/

While data on copper industry wages for foreign producers in subsequent years are not available, the International Labor Organization (ILO) does publish annual wage statistics for the "mining and quarrying" industries of some major foreign copper producing countries. These data may be used as a reference to wages in the copper industry itself. From this, it is apparent that Canadian wage levels

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18/ U.S. Bureau of the Census. 1981 Annual Survey of Manufactures. M81 (AS)-1 and personal communication with U.S. Bureau of Labor Statistics.

19/ Sousa, op. cit., p. 31. Note that these and the following comparisons of international labor costs only account for direct wage payments to workers and do not include additional non-wage benefits, for which data are not available. In general, additional compensation to U.S. workers exceeds that in most foreign copper-producing countries. According to the Bureau of Labor Statistics, for example, non-wage benefits accounted for 47.5 percent of total compensation paid to workers in all the nonferrous metals industries (SIC 333-335) in 1981, as opposed to 37.4 percent for the same sector of the Canadian economy. Approximately the same ratios probably apply to the copper industry itself. While non-wage benefits to individual workers are probably smaller in relation to total costs in the developing countries, companies in those regions often bear substantial "social infrastructure" costs, such as government requirements to provide housing, hospitalization and schooling to workers' families. Such costs are not usually borne by firms operating in the U.S. and Canada.

maintained approximately the same relationship to U.S. copper industry wages throughout the 1978 to 1981 period. Reflecting very high internal inflation rates, Chilean peso-denominated wages advanced more rapidly, albeit from a very low initial level. Thus, with the Chilean peso fixed to the dollar during most of this period, dollar-denominated wages in the "mining and quarrying" industry (converted at 1984 exchange rates) increased between 1978 and 1981 from 13 percent to 21 percent of the level in the U.S. copper industry (see table II:5).

Table II:5. Comparison of U.S. Copper Miners' Direct Wages with Wages Paid to Workers in the Mining and Quarrying Industries of Selected Countries (local wages converted to U.S. dollars at 1984 exchange rates)

	U.S. [a]	Canada[b]	Chile[b]	Peru[c]
1978	$18,185	$17,152	$2,303	$3,300
1979	21,156	18,617	3,010	n.a.
1980	22,456	20,839	4,441	n.a.
1981	26,262	23,176	5,405	n.a.

n.a. = not available.

(a) U.S. Bureau of the Census. Annual Survey of Manufactures, M81(AS)-1.

(b) International Labor Organization. Statistical Yearbook. 1981.

(c) Sousa, Louis J. The Copper Industry: Problems, Issues and Outlook. 1981.

Historically, the U.S. mining industry has been able to offset declining ore grades and rising labor costs with rapid increases in productivity. These improvements have been achieved primarily through large increases in equipment capacity, which have allowed each worker to process more tons of material per shift. In essence, the labor component of unit costs has been reduced by increasing the capital- and energy-intensity of the production system.

Gains in copper mining productivity, however, have slowed considerably in the last two decades. Annual increases in the output of ore per U.S. employee, which had averaged 2.5 percent during the 1960s, fell to less than half that level in the 1970s. More importantly, declining ore grades have kept average annual increases in the output of copper metal per employee throughout the 1960s and 1970s below the rate of increase in ore productivity. Labor productivity in terms of metal content, in fact, has shown very little improvement in the last two decades (see table II:6). It appears that the industry may have reached a point at which economies of scale and other techniques for improving efficiency are yielding diminishing returns in terms of copper productivity.

Table II:6. Average Annual Rate of Change in U.S. Copper Mining Labor Productivity (percent, based on output per employee)

	1960-1969	1970-1979
Crude Ore	2.5	1.0
Recoverable Metal	0.8	0.7

Source: Sousa, Louis. The U.S. Copper Industry. 1981.

Despite declining rates of improvement, however, the U.S. copper industry continues to be the most efficient miner of copper ores in the world. In 1982, domestic producers processed about 60 percent more ore per employee than Codelco-Chile, the lowest cost international supplier. With reductions in the U.S. labor force exceeding the decline in actual ore mined, this advantage grew in 1983 (see table II:7).

Table II:7. Labor Productivity of the U.S. Copper Mining Industry and of the Corporacion del Cobre de Chile (Codelco), 1982 and 1983 (thousand pounds per employee)

		Crude Ore	Refined Metal
U.S.	1982	15,900	71
	1983	19,600	95
Codelco	1982	9,900	86
	1983	10,100	88

Sources: International Trade Commission. Investigation TA-201-52, Unwrought Copper. Testimony of Leons Kovisors, MET Research, Inc. May 15, 1984. U.S. Bureau of Mines. CRS inquiry.

Superior U.S. productivity in terms of ore processed, perman, however, has not always translated into an advantage over Codelco-Chile in terms of the amount of refined metal produced per employee (see table II:8). 20/ This is the result of much higher Chilean ore grades, which allow Codelco to obtain about the same amount of copper metal with approximately the same work force, while mining and processing less than 70 percent as much copper ore as the U.S. industry.

20/ In this section, U.S. labor costs are compared only to Codelco-Chile's costs because employment and wage data are not available for Peru and because productivity in Canadian copper mines, which produce significant amounts of other co- and byproduct metals, are not directly comparable to the U.S. Codelco-Chile is the largest, lowest cost and most aggressive foreign supplier of copper to the U.S. market.

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Table II:8. Estimated Direct Labor Costs for the U.S. Copper Industry and for the Corporacion del Cobre de Chile, 1978-1983.

		1978	1979	1980	1981	1982	1983
Annual Wage [a]	U.S.	$18,185	$21,156	$22,456	$26,262	$27,785	$29,036
	Chile	3,455	4,515	6,662	8,108	6,828	5,724
Productivity [b]	U.S.	68.4	66.2	61.7	68.4	70.6	94.8
	Chile	70.6	66.2	66.2	70.6	86.0	88.2
Direct Labor Cost [c]	U.S.	.27	.32	.36	.38	.39	.31
	Chile	.05	.07	.10	.11	.08	.06
Ratio of U.S. to Chilean Labor Costs		5.4	4.6	3.6	3.5	4.9	5.2

(a) Annual straight-time wage earnings converted into dollars at 1984 exchange rates.

(b) Thousand pounds of refined metal per year divided by total employees.

(c) Straight-time wage cost per pound of refined metal produced.

Sources: U.S. Bureau of the Census. Annual Survey of Manufactures. Statistics for Industry Groups and Industries, M81 (AS-1).
International Trade Commission. Investigation TA-201-52, Unwrought Copper.
Testimony of Leons Kovisers, MET Research Inc. May 15, 1984.
International Labor Organization. 1981 Statistical Yearbook.
Personal Communication with the U.S. Bureau of Labor Statistics.

With these data on wages and productivity in both Chile and the United States, it is possible to make some rough estimates of the direct labor costs per pound of producing copper in each country. If it is assumed that Codelco-Chile's employees, like their counterparts in the U.S., earn about 50 percent more than the average worker in the "mining and quarrying" industry, and if it is also assumed that real, straight-time wages in Chile (adjusted according to the consumer price index, with peso-denominated wages converted to dollars at current exchange rates) have remained constant since 1981 (the last year for which published statistics are available), the time series shown in table II:8 can be constructed. These calculations show that Codelco-Chile's dollar denominated labor costs, which had stood at less than one-fifth the U.S. level in 1978, steadily increased relative to U.S. costs until 1981.

Since the onset of the 1981 recession, however, several developments in both countries have affected this trend. On the one hand, the completion of a number of investment projects, combined with reductions in labor force, have brought significant improvements in both countries' productivity. These advances have been particularly important in the United States where refined copper output per employee increased by nearly 40 percent between 1981 and 1983 (Chilean productivity improved by about 25 percent in the same period). On the other hand, the competitive advantage that the U.S. might have achieved from its superior gains in efficiency appears to have been more than offset by the depreciation of the Chilean peso in 1982 and 1983. Only an increase in Codelco-Chile's wages that substantially exceeded the Chilean inflation rate might have prevented the ratio of U.S. to Chilean labor costs per pound of copper from again rising to the unfavorable levels of the mid-1970s.

Changes in U.S., Canadian, and Peruvian labor cost differentials have probably been much more favorable to the United States in the most recent years. Because most Canadian copper workers are represented by U.S.-based unions, because U.S. and Canadian inflation has moved at roughly parallel rates, and because the Canadian dollar's depreciation against the U.S. dollar has been relatively moderate, dollar denominated unit labor costs in Canada are unlikely to have changed substantially since 1981. In Peru, the effect of the sol's depreciation has probably been offset by rapidly rising wages, bolstered by the politically powerful copper unions in that country, and by high rates of general inflation. Thus, increased productivity is likely to have improved U.S. labor cost competitiveness relative to Canadian and Peruvian copper producers more than has been the case relative to Codelco-Chile.

The Impact of Byproducts and Coproducts in Canada

While almost all U.S. and Latin American copper production comes from large, relatively low grade porphyry deposits, a large portion of Canadian output is derived from smaller but richer nickel-copper and copper-zinc massive sulfide deposits. About 15 percent of Canada's annual copper production, in fact, has come from INCO's nickel operations in Sudbury, Ontario, which also account for over 15 percent annual world production of nickel.

There are considerable difficulties in comparing the economics of copper production from mines in which copper is the primary commodity to those in which revenues from other products are of equal or greater importance. Since all the metals that are produced in the latter type of operation are mined and processed together in the early stages of production, costs can be assigned to one component of the mix such as copper in a number of different ways. In general, calculations as to the profitability of an operation can only be made by comparing the total costs of extracting and processing a polymetallic raw material with the total earnings from sales of all the commodities that are eventually supplied to the market. One can judge whether a copper mine is more profitable than a copper/gold/silver mine, but cannot directly compare the cost of copper in each operation.

To compare competitiveness of these dissimilar operations with respect to an individual commodity, an arbitrary decision as to how to assign costs to the commodity in question has to be made. One common approach is to assign all costs to a single commodity, usually the dominant metallic element. All earnings from the sale of other commodities produced concurrently in the same operation are then credited against the total cost of operations. The residual difference, which can be either positive or negative, is assumed to be the cost of producing the dominant metal commodity.

Rather curious results, unlike comparing costs and revenues for a simple metallic ore, can emerge from the use of this technique. The Canadian Centre for Resource Studies estimated that, because of high prices being realized for nickel, cobalt and other associated metals in a complex ore, Canadian nickel-copper operations' average break-even costs in 1979 were -$1.33 per pound of copper. 21/ In other words, co-product income by itself exceeded the average producer's total costs of production. Under this formula, at that particular time, these producers could have "lost" a dollar on every pound of copper they sold and still have retained a profit on their total operations.

While the other metal prices associated with copper production from massive sulfide deposits have declined considerably since the late 1970s, they still appear to contribute substantially to Canadian operations' competitiveness. In 1981, the Bureau of Mines estimated

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21/ Mackenzie, Brian. Canada's Competitive Position in Copper and Zinc Markets. Working Paper No. 16. Kingston, Ontario. Centre for Resource Studies. 1979. p. 20.

that average credits for co- or byproduct sales were equivalent to 90 percent of the Canadian copper industry's average mining and milling costs. (The value of coproduct sales from individual massive sulfide operations was, of course, much greater than this, since porphyry-based operations were included in this national aggregate). By contrast, sales of molybdenum, gold, silver and other byproducts from U.S., Chilean and Peruvian copper porphyry deposits amounted in 1981 to 23 percent, 19 percent and 12 percent respectively of those countries' average mining and milling costs of production (see table II:2). Clearly, the proportion of the total cost burden that must be carried by copper sales is considerably reduced for the massive sulfide operations when viewed in this fashion.

The effect of coproduct production on the ability of the copper component to compete in the marketplace, however, can vary considerably over time. Massive sulfide operations are particularly vulnerable because, as can be seen from the Canadian data in table II:2, the gross cost of smelting a polymetallic ore is much greater than is usually the case for the less complex, copper porphyry ores. These costs can only be tolerated because of the extra income that the massive sulfide operations derive from the sale of several different commodities. If the prices for the array of products are depressed simultaneously, the net profitability of mining and processing may not differ much from that of the copper industry in general. Thus, like many of the porphyry copper producers, INCO was forced to shut down its Sudbury operations in 1982 and 1983 because of the very low nickel and cobalt prices prevailing at the time.

D. The Primary Copper Smelting and Refining Industry

The U.S. copper processing industries have experienced a continuous loss of market share over the last few decades. A number of factors, both external and internal, controllable and uncontrollable, have contributed to this decline.

External Developments

Less than two decades ago, nearly all the major copper operations in the Third World were owned and operated by a relatively few European and North American multinational corporations. Viewing such arrangements as economically exploitative and in some countries encouraged by the growth of anti-colonial independence movements, developing country governments began in the mid-1960s to demand greater sovereignty over their natural resources. In the Western Hemisphere, these demands led to the nationalization of many of the most important Latin American copper operations, beginning with Chile's four largest producers in 1971 and followed by Peru's Cerro de Pasco (Centromin) corporation in 1974. With similar actions being taken elsewhere, the majority of Third World production had come under government control by the end of the 1970s. In 1981, operations in which national governments had over 50 percent interest accounted for approximately 35 percent, 30 percent and 24 percent of all market-economy world production capacity in copper mining, smelting, and refining respectively. 22/

These changes in the structure of the international copper industry have had a number of negative impacts on U.S. producers. Where the nationalized operations had been owned by U.S. corporations (as was the case for all of the operations mentioned above), the direct investment loss was in some cases substantial. This was particularly true for the Anaconda Corporation which, because of its protracted resistance to the "Chileanization" campaign of the 1960s and the ill will that resulted, received very little compensation for its expropriated assets. 23/

The subsequent emphasis that Third World producers have put on the expansion of their processing capacity has probably been of greater long-term importance to U.S. smelters and refiners. During the 1970s, smelter and refinery output declined in both the U.S. and Canada. In contrast, Chilean and Peruvian processing capacities expanded rapidly throughout the decade, with their combined refinery output more than doubling between 1968-70 and 1978-80 (see table II:9).

Table II:9. Production of Copper in Chile and Peru, 1968-70 and 1978-80 (three year averages in metric tons of contained copper)

		1968-70	1978-80	% Change
Mines	Chile	683,778	1,054,600	54
	Peru	210,522	378,114	79
	Total	894,300	1,432,714	60
Smelters	Chile	645,480	942,467	46
	Peru	140,764	337,102	139
	Total	786,244	1,279,569	63
Refineries	Chile	436,315	779,767	79
	Peru	36,381	213,296	486
	Total	472,696	993,063	110

Source: U.S. Bureau of Mines. Minerals Yearbook [various issues].

22/ Radetzki, Marian. State Enterprises in International Mineral Markets. International Institute for Applied Systems Analysis. 1983. [Unpublished]. pp. 42-44.

23/ Moran, Theodore. Multinational Corporations and the Politics of Dependence: Copper in Chile. Princeton University Press. 1974. p. 146.

These increases in foreign smelter and refinery output affected the U.S. industry in two related ways. First, the integrated multinationals' loss of company-owned ores and concentrates, combined with new demand for those products from foreign processors, tended to decrease the volume of foreign copper raw materials available for use by U.S. producers of smelted and refined copper. This was particularly the case for custom smelters and refiners, who have to acquire substantial portions of their raw materials in international market. Over the course of a decade or so, this effect tended to push total U.S. processing output down to or even below the level of U.S. mine output (see table II:10).

Second, the competition U.S. producers faced in consumer markets has intensified with the growth of foreign output. While Latin American smelting and refining capacity was expanding rapidly, U.S. and world consumption growth averaged under one percent annually in the latter half of the 1970s. With low mining and milling costs, some of the larger, integrated foreign producers appear to have been able to absorb the resulting drops in real copper prices without sacrificing profitability. Much of the domestic industry, on the other hand, found itself being priced out of an over-supplied market (see tables II:2 and II:3).

Labor Costs

Real labor costs in U.S. smelters and refineries increased steadily until recent years. During the 1970s, total labor productivity in smelting and refining grew by less than one-half of a percent per year, while workers' gross earnings increased by about two percent annually. Between the late 1960s and late 1970s, the number of nonproduction workers grew from 14 to 15 percent to 19 to 22 percent of total employment in the industry. As a result, real labor costs per pound of copper for all workers increased by an average of 1.3 percent per year throughout the last decade. 24/ In 1981, the average yearly compensation in this industry was $34,439, again more than half as much as the average manufacturing wage for the U.S. as a whole. 25/

Although disaggregated data for the international processing industry are not available, wage differentials between U.S. and foreign smelting and refining producers were probably matched by the differentials in mining, discussed above. If so, the competitive position of domestic smelters and refineries was probably more adversely affected by rising U.S. wage rates, since their productivity increases were smaller than in domestic mines.

24/ Sousa. op. cit. pp. 31-32.

25/ U.S. Bureau of the Census. 1981 Annual Survey of Manufactures. Statistics for Industry Groups and Industries. M81(AS)-1. pp. 29, 33.

Table II:10. Average Annual U.S. Supply of Copper, 1956-60, 1966-70, 1976-80 (metric tons of contained metal)

	1956-60	1966-70	1976-80
Ores and Concentrates			
Production [a]	941,225	1,242,966	1,273,004
Indicated Net Imports (Exports) [b]	253,518	(5,440)	(125,370)
Smelters			
Production	1,194,743	1,273,526	1,147,634
Indicated Net Imports (Exports) [c]	50,841	175,446	238,174
Refineries			
Production	1,245,584	1,412,972	1,385,808
Net Imports (Exports)	(128,324)	11,581	292,053
Total Available Supply [d]	1,801,895	2,097,892	2,245,438

(a) Domestic ores and concentrates used in U.S. smelters plus exports of U.S. ores and concentrates.

(b) Indicated surplus or deficit is the difference between the copper content of mine production and the copper content of smelter production.

(c) Indicated surplus or deficit is the difference between the copper content of refined production and the copper content of smelter production.

(d) Total available supply is defined as domestic production of refined copper plus imports of refined copper. Exports are included on the assumption that they would be available in the U.S. if demanded.

Source: U.S. Bureau of Mines. Minerals Yearbook [various issues].

Energy Costs

As with the mining industry, energy costs at U.S. smelters and refineries rose rapidly in the last decade. Since the intensity of energy consumption did not increase for processing as much as for mining and milling, most of the cost increase was simply the result of higher unit costs for the various energy sources. As was mentioned above, domestic prices for natural gas, which accounts for over 60 percent of smelter and refinery energy consumption, nearly tripled between 1978 and 1983.

Environmental Regulations

The Clean Air Act (CAA) establishes strict requirements for the recovery of sulfur dioxide (SO2) gases that are emitted during the copper smelting process. Since these regulations are much more stringent than those that apply to some major foreign competitors, they are considered by many to impose a significant cost disadvantage on domestic producers.

Industry sources have estimated that the additional cost to the domestic industry of full compliance with the CAA's National Ambient Air Quality Standards (NAAQS) may eventually amount to $.15 per pound of copper, or approximately 14 percent of total average U.S. production costs. 26/ Other government sources, on the other hand, have indicated that the $.05 to .1[illegible] per pound of copper range might be a more accurate estimate. 27/ Data on the costs of operating sulfuric acid plants at smelters producing different SO2 offgas concentrations suggest, in fact, that the weighted average cost for full compliance with the NAAQS at all domestic operations would be around $.09 per pound of copper. 28/

Since U.S. capacity is composed of a number of different plant types, these costs may vary considerably. For the oldest reverberatory furnaces, where low offgas concentrations make efficient operation of a sulfuric acid plant nearly impossible, the costs of full compliance could be over $.12 per pound. Some firms have stated that this expense would be prohibitive, and that some of these plants would be permanently closed down rather than retrofitted. In 1983, reverberatory furnaces accounted for about 65 percent of U.S. production capacity.

The costs of full compliance for some of the more modern U.S. smelters would, on the other hand, be considerably lower. For those plants that have installed the newer, energy-efficient, "flash" furnaces or continous smelting systems, the added costs of meeting the NAAQS in full might be around $.03 per pound. In 1983, about 30 percent of domestic capacity was supplied from these types of operations.

26/ Ridinger, David. Cost of Regulations to the Mining Industry. American Mining Congress Journal. February 1980. pp. 42-44.

27/ Arizona Department of Health Services. Third Annual Report on Arizona Copper Smelter Environmental Control Technology. 1979. p. 56.

28/ CRS calculations based on data contained in Everest Consulting Associates, Inc. and CRU Consultants, Inc. The International Competitiveness of the U.S. Non-Ferrous Smelting Industry and the Clean Air Act. April 1982. pp. 3-45, 3-46.

To date, many of the expenditures that will be required to meet the NAAQS have not been made. Accordingly, Arizona Department of Health Services officials estimated that the total additional cost of these regulations to the domestic copper industry had only amounted to an average of about $.03 per pound.

Because detailed data on the environmental requirements as well as performance of foreign copper producers are not available, it is impossible to accurately assess international differences in pollution control costs. Incomplete information suggests that Chilean and Peruvian smelters recover between one-third and one-half as much SO_2 per pound of copper as is currently recovered by domestic producers. This would indicate that pollution control in these countries, while not absent, has not progressed as far as in the U.S. Canadian performance is probably closer to the U.S., although production of coproducts makes it difficult to allocate SO_2 recovery costs to individual commodities such as copper.

If we assume, hypothetically, that no further industry expenditures had been required after 1981 to meet the NAAQS, would the U.S. copper industry been encountering its current difficulties? 29/ The approximately $.06 per pound additional average costs that these standards would require of U.S. operations (calculated as the difference between the $.09 in total NAAQS costs and the approximately $.03 that had already been spent by 1981) represented an estimated 21 and 17 percent respectively of the 1981 cost differentials (at the refinery) between the average U.S. producer and his Chilean and Canadian counterparts (see table II:2). While these figures vary for individual operations, (for example, the over $.12 per pound cost of compliance for older furnaces), it would seem that a balancing of international environmental standards or public absorption of costs would substantially alter average U.S. cost competitiveness with regard to trade with Peru, but not with Canada and Chile.

F. The Costs of Purchased Capital Goods

The costs of investment goods purchased by the copper industry also rose significantly over the years. In some cases, this was due to developments within the industry itself. It has been estimated, for example, that while total exploration expenditures by the nonfuel minerals industries in the western U.S. grew by about 250 to 300 percent in real terms between 1955 and 1969, the gross value of all the resulting discoveries grew by only about 150 percent.

29/ The implicit corollary to this query is that the domestic copper industry's total average international cost disadvantage would not be entirely offset if foreign producers were subject to the same stringent environmental regulations as apply in the U.S.

Because historically intensive exploration has made it increasingly difficult to locate real bonanzas, then, the real cost of discovering additional units of marketable copper in the U.S. has probably increased by over 50 percent in the last several decades. 30/

Primarily because of the availability of a number of already identified but still undeveloped high grade deposits, the increase of exploration costs in Canada, Chile, and Peru has probably been less rapid than in the U.S. However, since the largest portion of exploration costs occurs after a deposit has been located, (i.e. extensive drilling, assaying, etc.) and since some Canadian and Latin American prospects are in remote, undeveloped regions, their total costs may occasionally still approach the levels common in the U.S.

Another important problem, exogenous to the copper industry itself, has been the rapid price escalation of capital goods purchased for metals mining and processing. In the mining industry alone, these costs grew by an average of 12.6 percent annually, or over 5 percent more than inflation each year during the 1970s. In the same period, the prices of capital goods purchased by all U.S. manufacturing industries, which might reflect the trend in costs of copper smelters and refiners more accurately, increased at an average real rate of about 2 percent per annum. 31/ Thus, the real costs of purchased capital goods in mining and in general manufacturing (compared to the GNP deflator) rose by over 75 percent and 25 percent respectively in the 1970s. At the same time, copper prices in constant dollars have declined by about one-third. The result of these changes has been a rapid increase in the "specific investment cost" of establishing new copper production capacity.

It has generally been assumed that investment costs in industrialized countries like the U.S. are lower than in competing developing countries. This was reasoned to be the case partly because many developing country producers have limited indigenous capital goods sectors and must import the bulk of their needs from the U.S. and other industrialized countries. As a result, such producers not only bear the inflated procurement costs, but also the sometimes substantial cost of transportation.

Of even greater importance, however, is the advantage that domestic producers often enjoy by having relatively well developed infrastructure already available. A 1974 U.S. Bureau of Mines report which compares investment costs for developing identical porphyry copper deposits in the western continental U.S. and in Alaska illustrates this

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30/ Sousa. op. cit. p. 38.

31/ U.S. Department of Commerce. Bureau of Economic Analysis. Survey of Current Business [various issues].

difference. While the climatic conditions had some impact, the need to build new roads, railroads, power plants and other support facilities was the largest factor in making the costs of the Alaskan operation more than double the costs in the lower 48 states. 32/ These differences are often magnified in "greenfield" projects in the Third World, where the operator is often required to install such "social infrastructure" as schools, hospitals and housing. As a result, the Bureau of Mines estimates that the average infrastructure cost per annual ton of copper capacity for new projects in the continental U.S. would be only about $125, compared with average costs of approximately $1600 and $1800 in Chile and Peru respectively (see table II:11). 33/

Table II:11. Average Specific Investment Costs for Greenfield Copper Mine Projects (January 1981 dollars per annual ton of refined copper capacity)

	Exploration	Acquisition & Development	Mine	Mill	Infra-structure	Total
U.S.	$174	$1195	$1221	2805	125	$5520
Canada	101	875	978	2566	269	4789
Chile	147	967	810	1473	1578	4975
Peru	69	533	1116	1449	1810	4977

Source: U.S. Bureau of Mines. Minerals Availability Program. Unpublished data.

Despite these substantial advantages, however, the Bureau of Mines data show that total domestic costs for new copper capacity are probably comparable with and, in fact, slightly above the averages for new foreign operations. The principal factor offsetting the savings from available infrastructure appears to be the much higher costs of constructing new copper milling plants in the U.S. This, in turn, reflects lower average ore grades, which make it necessary to add extra crushing and flotation facilities for equivalent levels of copper production, as well as the greater capital intensity of U.S. facilities and higher construction costs in the U.S.

Of course, with the current low prices and overcapacity, very few "greenfield" copper projects are likely to be initiated in the near future. The majority of new investments in the remainder of this decade will be designed either to expand, replace, or improve outmoded facilities or, particularly in the U.S., to bring existing plant into compliance with environmental regulations.

32/ Bottge, R. G. Comparative Porphyry Copper Mining and Processing Costs - Alaska and Arizona. U.S. Bureau of Mines. Information Circular 8656. 1974.

33/ For further discussion of the estimated capital costs for developing U.S. copper deposits, see: U.S. Bureau of Mines. Copper Availability--Market Economy Countries. IC 8930. 1983. pp. 21-22.

Information on the costs of such projects is occasionally published in the trade journals. But because those costs vary considerably with the type and age of the individual existing facilities, as well as with each firm's strategic objectives, simple comparisons of the expenditure per ton of output are rarely of much value. In general, however, the total investment costs of expansion or retrofit projects in developing countries are likely to be smaller in comparison to U.S. costs than is true for "greenfield" projects. This is the case, first, because much of the advantage that new domestic operations might derive from the availability of public infrastructure is lost when foreign producers build on operations that are already in place. As a result, developing countries' advantages of lower construction costs and of less complex processing requirements might become more significant in the aggregate. Such advantages might be only partially offset by the additional costs of importing capital goods (see table II:11).

III. LEAD*

A. Introduction

The U.S. lead industry provides a different perspective than does copper on the current competitive position of U.S. metals industries. As a leading world producer, with relatively low quality ores but nonetheless low cost mines, the United States is not overly threatened by competition from high-grade mines overseas. Energy and labor costs are not as adversely significant elements in the industry's competitiveness as is the case with copper.

Like copper, however, the competitiveness of the lead industry has been affected by changing inflation and currency exchange rates. Similarly, U.S. smelter and refinery output in the future is likely to be tied more to the level of domestic mine production than in the past, reflecting the growth of foreign capacity. However, the financial outlook of this sector appears healthier than its copper counterparts. The key elements affecting the future health of the domestic lead industry probably have less to do with overseas producers, than the indirect impact of federal regulations setting acceptable lead levels in the workplace and in gasoline.

B. Market Share and Current Economic Conditions

As an employer, the domestic primary lead industry is the third largest U.S. base metals industry, providing about 20 percent as much employment (approximately 4600 workers in 1983) as the copper industry. By contribution to GNP, it is the fourth largest, adding about 20 percent of the market value ($300 to $500 million annually) as is created by the copper or the iron ore mining industry. 1/ With output exceeding one million tons per year, however, the industry is the largest producer of lead in the world.

1/ Employment data are from U.S. Bureau of Mines. Mineral Commodity Summaries. 1984. p. 86. Value of production data are from U.S. Bureau of Mines. Minerals Yearbook - 1982. Vol. I, Metals and Minerals. p. 30.

*Prepared by John G. Ellis, Research Assistant, Office of Senior Specialists.

In the last decade, the lead mining industry has shown considerably greater market strength than its counterparts in the other base metals industries. This strength has been largely attributable to the discovery and development in the late 1960s of the New Missouri Lead Belt (the "Vibernum Trend"), which opened up sizeable new reserves of high quality ore. By 1970, domestic mine production had nearly doubled from the 1960 level, increasing its contribution from under one-quarter to about one-third of total annual available domestic supply (see table III:1).

While starting from a higher absolute level of output, growth performance in the primary lead smelting and refining industry has not matched that of the mining sector as a whole. In the late 1960s, U.S. refinery production exceeded the lead content of domestic mine output by over 100 thousand metric tons per year. This was made possible by the importation of considerable quantities of ores and other unprocessed lead materials from foreign producers, primarily in the Third World, whose mine output exceeded in-country processing capacities. Perhaps because of the growth of foreign capacity or because of the increasing costs of transporting raw materials to inland U.S. lead smelters and refineries, imports into the United States have declined by more than 70 percent in the last two decades. Thus, as with the copper industry, the apparent long-term trend is

Table III:1. The U.S. Industry's Contribution to Average Annual Available Domestic Lead Supply, 1958-60, 1968-70, and 1978-80

	1958-60		1968-70		1978-80	
U.S. Production	'000 tons	%	'000 tons	%	'000 tons	%
Mine Output	233	23	435	32	535	36
Primary Refineries	370	36	550	41	565	38
Secondary Refineries	400	39	530	40	749	51
U.S. Imports						
Ores, mattes, etc.	155	15	77	6	45	3
Scrap	7	1	4	--	3	--
Bullion, pigs and bars	250	25	261	19	165	11
Total Imports	412	41	342	25	213	14
Total Supplya/	1020	--	1341	--	1479	--

(a) Total average annual available domestic lead supply is defined as total U.S. primary and secondary production, plus imports of lead bullion, pigs and bars. Primary refinery production includes domestic and foreign material, and antimonial lead.

Source: U.S. Bureau of Mines. Minerals Yearbook [various years].

for U.S. primary lead smelter and refinery output to be more closely tied to the level of domestic mine production than was the case in the past.

The market price of lead, like that of most of the other base metals, was severely depressed during the 1982-83 recession. However, while the average 1983 price of about $.22 per pound was well below the Bureau of Mines' estimate of average 1981 domestic production costs (see table III:2), individual performance within the industry appears to have varied considerably. On the negative side, the nation's second largest mine, where operations were initially suspended in March 1983, remained shut down in 1984 because of continued market losses. 2/ Only by mining its higher grade ores (and, thereby, by lowering the average grades that will be mineable in the future) has the largest domestic operation been able to sustain output at historical levels. 3/ On the positive side, however, the largest integrated domestic producing company, which currently operates five mines in the Missouri district, continued to report positive, though declining profits. 4/ It is likely that the aggregate operating costs

Table III:2. Estimated Total Costs for Producing Lead Mines (1981 dollars per pound of recovered lead)

Cost Factor	United States	All Foreign
Mine, operating	$.10	$.17
Mill, operating	.06	.06
Processing	.11	.16
Other	.06	.09
Total operating	.34	.45
Taxes	.03	.04
Byproduct credits	.13	.26
Net cost	.24	.23
Total costs	.27	.30

Source: U.S. Bureau of Mines. Primary Lead and Zinc Availability--Market Economy Countries. Minerals Availability System. IC 9026. 1985. p. 27.

2/ Sohio. 1984 Annual Report. p. 33.

3/ Amax, Inc. Securities and Exchange Commission Form 10-K. March 24, 1984. p. 13.

4/ Fluor Corporation. 1983 Annual Report. p. 15.

operating costs at its lead operations were still near, and at some of the more efficient locations perhaps below, the prevailing price at that time. Prices continued to decline and in 1985 only averaged $.17 per pound, or below the levels experienced in the great depression.

In its present form, with most of the remaining primary smelters and refineries closely tied to low cost mines, the domestic lead industry is considered to be relatively secure from further import penetration. The Bureau of Mines' MAS data show domestic producers' average 1981 costs of production to be $.03 below the average for all foreign producers (see table III:2). If maintained, this margin, combined with the current duty of about $.01 per pound on imports and with the $.02 to $.03 costs per pound of ocean shipping from leading lead exporters' ports, will mitigate against any major, indefinite increases in imports. 5/

Clearly, however, the apparent cost advantage that U.S. producers enjoyed over the average foreign operator in 1981 was narrow. In discussing the economic viability of the lead industry, it should be kept in mind that significant shifts in one or two of the domestic industry's cost factors have the potential for creating serious competitive vulnerabilities in the future.

For purposes of comparing the domestic lead industry with foreign industries, competing production from Canada, Mexico, and Peru is the most important. Together, these three countries accounted for over 75 percent of aggregate U.S. lead imports between 1980 and 1983. In that period, Peru, a traditional supplier under long-term contracts to domestic producers, was the most important supplier of low value-added materials, shipping 45 percent and 51 percent respectively of U.S. lead concentrates and base bullion imports. Canada and Mexico supplied the bulk of the more processed products, accounting for a combined 80 percent of U.S. imports of pigs and bars and 85 percent of imported sheets, pipe and other semi-fabricated materials. 6/

C. The Lead Mining Industry

The U.S. lead industry is unusual compared to its major foreign competitors in that over 90 percent of domestic production comes from mines in which lead is clearly the dominant product. By contrast, almost all foreign production comes from operations in which zinc, silver and other metals are equal or, quite often, the greater revenue

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5/ CRS Inquiry of U.S. Bureau of Mines, July 10, 1984, and U.S. Bureau of Mines. Mineral Commodity Summaries. 1984. p. 86.

6/ U.S. Bureau of Mines. Minerals Yearbook - 1983. Vol. I, Metals and Minerals. p. 553.

earners. This difference is directly attributable to the differing geological characteristics found among the various countries' resources.

Over 90 percent of U.S. production now comes from Missouri where, as noted earlier, the discovery of the Vibernum Trend led to a major expansion of productive capacity in the late 1960s and early 1970s. This is a striking example of how successful exploration can after many decades still change a nation's mineral productive capability. The ore grade of these deposits is, by international standards, relatively low: containing from 3 to 8 percent lead, under 1 percent zinc, and traces of nickel, cobalt, silver and a few minor metals. Occurring in extensive, relatively well-defined units, however, they lend themselves to a high degree of mechanization during the mining process. The mineralogical simplicity of the ores also increases the efficiency of beneficiation and smelting. 7/

By contrast, typical deposits in Canada and Mexico, while of higher average ore grade, are generally more complex than the Missouri deposits. In Canada, the largest lead producers mine massive sulfide deposits containing 3 to 5 percent lead and 5 to 15 percent zinc. In Mexico, highly irregular deposits containing 10 to 30 percent combined lead and zinc, 3 to 5 percent copper and 5 to 50 ounces of silver per ton account for the bulk of lead output. Similar operations exist in the western U.S., accounting for 5 to 10 percent of annual production. 8/ Some of these deposits are classified as silver operations because revenues from the sale of that metal typically exceed revenues from both lead and zinc.

Labor and Productivity

Because of the variations in producing ore bodies, data on mine productivity are not available and, in any case, would have little practical meaning. In mines which contain high byproduct silver values, much less ore must be processed to make lead production profitable than must be processed in mines where lead is the principal revenue earner. Thus, whereas less than 1300 U.S. miners in Missouri produced about 408,000 metric tons of lead in 1983, for a total of over 300 metric tons per worker, medium sized lead-silver mines in

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7/ For geological characterizations of lead resource types, see Donald A. Brobst and Walden P. Pratt. United States Mineral Resources. U.S. Geological Survey Professional Paper 820. 1973. pp. 319-320.

8/ Brobst and Pratt. Professional Paper 820. pp. 321-323.

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Mexico have remained profitable with outputs of only 50 to 100 metric tons of lead per miner. 9/

Of course, the lower metal output of Mexican miners also can be tolerated in the marketplace owing to the much lower wages they command. While U.S. lead miners earn, on the average, about 75 percent of what domestic copper or iron miners make, their annual earnings are still double or triple the earnings of their Latin American counterparts (who earned around $6,000 to $7,000 each in 1983). 10/

Canadian wages, on the other hand, come closer to the U.S. levels. The annual metal output of Canadian lead miners is also closer, but still less than the U.S. average. Here too, however, the higher content of zinc and other co-products in Canadian deposits makes less lead output per worker economically possible.

The above would seem to indicate that U.S. lead miners are vulnerable to increases in foreign miners' productivity, which might then make domestic labor costs per pound of lead produced uncompetitively high. This may not be as much a threat in the lead industry, however, where significant differences between the domestic and foreign reserve bases exist. Unlike the copper industry where major competition comes from countries with superior ore bodies of the same geologic type in the U.S. mines, lead deposits in the United States are of a different type, amenable to mechanized excavation and, hence, to very high levels of worker productivity. In many foreign operations, the complexity of the ore bodies presents certain immutable barriers to using any current technology for advancing productive efficiency. This is particularly true for the relatively small replacement deposits upon which much Mexican and Peruvian lead production is based. These variations between U.S. and foreign reserves helps to explain the substantially lower costs of mining in the United States despite much higher wage rates (see table III:2).

Energy

The lead industry as a whole consumes less energy per pound of metal produced than any of the other domestic metals industries. Approximately 5,000 British Thermal Units (Btus) are required at the

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9/ U.S. employment data from Missouri Department of Labor and Industrial Relations, CRS inquiry, May 28, 1984. Information on foreign productivity from response to CRS inquiry by U.S. Bureau of Mines, June 3, 1984.

10/ Missouri Department of Labor and Industrial Relations and of the U.S. Bureau of Mines, in response to CRS inquiry.

mining and milling stage to produce a pound of lead. By contrast, domestic copper mines and mills consume about 25,000 Btus per pound of copper output. 11/

The principal reason for this significant difference across industry energy intensities is the higher average ore grade exploited by the U.S. lead industry. With an average grade of over 5 percent lead in currently producing domestic lead mines, as opposed to 0.5 percent in the copper industry, the lead producers must mine, grind and process only one-tenth as much material to recover the same amount of metal from the ore body. Other factors that contribute to the lower energy intensiveness of lead production are the greater simplicity of lead grinding and flotation circuits and the infeasibility of introducing labor-substituting, energy-intensive technologies such such as those that are used in open pit copper mining. As a result, domestic lead producers were much less vulnerable to the loss of the United States long standing advantage in energy costs.

Precise international comparison of total energy costs is made difficult by the scarcity of data on foreign prices and lead industry consumption. Nonetheless, as in the case of copper, domestic energy prices appear to have risen more rapidly in recent years than has been the case overseas. Incomplete information indicates that the cost of electricity purchased by domestic lead producers may be as much as 30 percent higher than the cost to Canadian and Mexican producers. 12/ This is a significant difference, since electric power represents almost two-thirds of the energy consumed by domestic lead and zinc mining industries (disaggregated data for the individual sectors are not available). 13/

The abundance of indigenous petroleum and natural gas supplies in Mexico and Peru may contribute to a further advantage in unit energy costs. It has been reported that the Mexican national oil company, Pemex, was furnishing heavy fuel oil in 1984 to a wide range of its domestic industries at about $1.25 per barrel, or about 4 percent of the price charged to its foreign customers. 14/ While the U.S. Commerce Department has ruled, in regard to a petition filed by the

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11/ U.S. Bureau of Mines. Mineral Facts and Problems. Bureau of Mines Bulletin 667. 1975. p. 605.

12/ Response to CRS inquiry by U.S. Bureau of Mines, June 3, 1984.

13/ U.S. Bureau of the Census. 1977 Census of Mineral Industries. 1981. pp. 5-4, 5-5.

14/ Laurence E. Hirsch. Domestic Cement Industry Plagued by Mexican Imports. American Mining Congress Journal. March 21, 1984. p. 15.

domestic cement industry, that such energy pricing practices are not subject to "countervailing" tariff duties under current U.S. law, domestic producers claim that they are unfairly disadvantaged in international competition by this large differential in energy prices.

However, if the energy required per unit of metal output is greater than in the United States, then access to lower priced fuels does not necessarily mean that foreign producers' total energy costs will be lower. In fact, Bureau of Mines' engineering cost estimates, show that in 1981, average total energy costs per unit of lead ore mined and milled in the United States were 47 percent and 34 percent, respectively, below the Canadian and Mexican averages. 15/ The corresponding differentials in terms of cost per unit of metal produced will, or course, be reduced by those countries' higher ore grades. Nevertheless, it appears that the superior efficiency with which energy is consumed by the U.S. lead industry for the most part offsets any domestic disadvantage in terms of the market price of purchased energy. It is not clear whether foreign producers may in the future be able to improve their competitiveness by bringing unit energy consumption closer to U.S. standards. To a certain extent, however, the greater structural and metallurgical complexity of foreign ore bodies will still impose certain physical limitations on energy productivity in the same way that it constrains improvements in labor productivity.

The Impact of Byproducts and Coproducts on Competitiveness

Even more than in the copper industry, the presence of other revenue earning minerals affects the profitability and competitiveness of lead mining operations worldwide. In Canada, the world's fourth largest mine producer of lead, six of the seven largest lead producing operations actually have the capacity to produce more than twice as much zinc as lead. 16/ Nearly 20 percent [illegible] Mexico's current lead output may be classified as "byproduct" from a single, very large new silver mine (Real de Angeles). 17/ Both these types of operations also account for the bulk of Peruvian production.

The U.S. lead mining industry is, in fact, almost unique in its heavy reliance on lead ores that contain relatively small quantities of zinc, silver and other byproduct metals. In 1982, zinc output from the eight operating lead mines in Missouri amounted to only 13

15/ U.S. Bureau of Mines. Minerals Availability Program. Unpublished data.

16/ Energy Mines and Resources Canada - Minerals. Canadian Mineral Survey 1983. February 1984. pp. 27-30.

17/ U.S. Bureau of Mines. Minerals Yearbook, 1982. Vol. III, Area Reports: International. p. 631.

percent of total lead production, on a contained metal basis. The amount of silver recovered from these operations was, by international standards, similarly small. As a result, the Bureau of Mines estimates that the credit from byproduct sales in the average foreign lead mine were double the domestic average in 1981 (see table III:2).

As was mentioned above, potential and actual differences in productivity make it possible for operations based on different ore grades to remain profitable in the same, international market. The lower average total costs of lead production in the United States despite a lower average metal content in ore, provides direct evidence to support this principle. In monitoring dynamic changes in U.S. competitiveness, however, the differing impacts of developments in other metals markets on the profitability of foreign lead operators must be kept in mind. An improvement in zinc prices, unaccompanied by an increase in lead prices, will tend to improve the cost competitiveness of Canadian, Mexican and Peruvian lead-zinc mines relative to the lead mines of Missouri. While such conditions may induce foreign producers to reduce the ratio of lead to other coproduct output as much as is technically feasible, the improved earnings capability of the operation as a whole may, in many cases, contribute to significant reductions in the effective marginal cost of lead production.

Inflation and Exchange Rate Fluctuations

Since the mid-1970s, the competitiveness of the U.S. lead industry has been affected by changing inflation and currency exchange rates in much the same way as the copper industry has been affected. Canadian prices converted to U.S. dollars rose slightly slower than the U.S. Consumer Price Index (CPI) before 1981, and slightly faster in 1982 and 1983. These differences are so small, however, that they are unlikely to have had any significant effect on U.S.-Canadian cost competitiveness in lead production over the course of the entire 1977 to 1983 period.

As is true for other basic metal industries, inflation and exchange rate changes have a negative impact on the U.S. lead industry's cost competitive position vis-a-vis the developing countries. Between 1977 and 1981, the Mexican inflation rate was about double the rates in both the United States and Canada. Yet, as is evident in table III:3, the Mexican peso was relatively stable against the dollar, depreciating only about as much as the Canadian dollar over the five year period before 1981. Thus, Mexican prices converted to U.S. dollars rose much more rapidly than the U.S. CPI, and the cost competitiveness of the Mexican lead industry relative to the United States tended to decline as a result.

By 1982, however, the decline of the Mexican economy and the apparent inability of the government to meet its international payments obligations brought a growing awareness that the peso had become greatly overvalued relative to the dollar. As part of a U.S.- and IMF-sponsored financial rescue plan, the peso was allowed to depreciate by 100 percent against the dollar in both 1982 and 1983. This depreciation was accompanied by (and was probably instrumental in encouraging) an acceleration of the Mexican inflation rate. Nonetheless, because depreciation of the peso has been so substantial, the Mexican CPI converted to dollars declined by 38 percentage points between 1981 and 1983, tending to improve Mexican lead producers' dollar-denominated cost position vis-a-vis their U.S. competitors. The actual magnitude of this effect depends on the extent to which Mexican lead producers have been dependent on scarce and more expensive materials, spare parts and other capital goods imports. A high degree of import dependence would tend to offset much of the cost advantage derived from the declining relative value of the peso.

Table III:3. Indexes of the Price of Lead and of Consumer Prices (CPI) Converted to U.S. Dollars in Lead Producing Countries, 1977-1983

			Canada			Mexico		
	Price Of Lead	U.S. CPI	CPI	Exchange Rate a/	$CPI b/	CPI	Exchange Rate a	$CPI b/
1977	84	67	68	92	74	45	92	48
1978	90	72	74	100	74	52	93	56
1979	164	80	81	98	83	62	93	66
1980	124	91	89	101	88	78	94	84
1981	100	100	100	100	100	100	100	100
1982	74	106	111	104	107	159	225	71
1983	57	109	117	104	113	384	482	62

(a) Local currency per U.S. dollar. A rising index means depreciation of the local currency and appreciation of the dollar.

(b) The index of foreign consumer prices converted to dollars is obtained by dividing the foreign CPI by the exchange rate in local currency per dollar and multiplying by 100.

Sources: International Monetary Fund. International Financial Statistics. U.S. Bureau of Mines. Mineral Commodity Summaries.

Market Structure and Competitiveness

The future competitiveness of U.S. lead producers is expected to still benefit from the large size of domestic deposits and from the low average production costs deriving from the geological character of domestic deposits. However, even assuming that the competitiveness of

U.S. producers vis-a-vis foreign producers does not decline as a result of increasing foreign productivity, monetary developments, gains from byproduct credits, or alterations in relative energy costs, U.S. producers will be competing in a slow growth market. Lead use as a gasoline additive, which accounted for 8 percent of U.S. demand in 1983, has been steadily declining since the early 1970s. The U.S. Environmental Protection Agency is currently reviewing whether to completely ban the use of lead in gasoline in the future. The Bureau of Mines also projects that the market share met by primary lead will fall to 45 percent by the year 2000, compared to the 55 percent average from 1973-83.

As a result of changes in end-use, the average annual rate of growth of primary lead demand in the United States is estimated to be zero from 1983 to 2000. [18] Primary lead demand in the rest of the world is expected to be higher, but still modest at 1.3 percent rate of growth over the same period. The stagnant nature of the U.S. market means that any deterioration in the competitiveness of U.S. producers will be more sharply felt than would be the case if it occurred in the face of growing demand.

D. Primary Smelting and Refining

Primarily because of the continued growth of foreign capacity, U.S. primary lead smelting and refining output is unlikely in the future to exceed domestic mine output by the margins that prevailed in the 1950s and 1960s. With access to more competitive raw materials supplies at home, however, the financial outlook for domestic lead processing operations, assuming that there are no major changes in the economic environment, is brighter than for their counterparts in the copper industry.

Energy

As in the mining sector, lead smelters and refiners use considerably less energy per pound of metal output than do copper producers. The reasons for this superior performance in both stages of production are similar: while richer ores provide an advantage to lead miners, the concentrates that feed primary lead smelters generally contain about three times as much metal per ton (around 75 percent lead content) as is contained in typical copper concentrates (about 25 percent copper). The energy savings that result from the ability to process less material per unit of metal output, however, are somewhat offset by the greater energy intensity per ton of raw material of lead processing technologies. On balance, lead smelters and refiners consume about 40 percent as much energy (10,000 Btus) per pound of lead produced as copper smelters and refineries require for each pound of copper (24,000 Btus). 19/

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[18] Bureau of Mines. Lead. Preprint from Bulletin 675. Mineral Facts and Problems. 1985 ed. p. 18.

In the traditional lead smelting process, the finely ground lead concentrates are agglomerated in sintering machines. This technology requires a considerable amount of fossil fuel energy, particularly in the form of natural gas. Given the importance of this component, the availability of relatively inexpensive energy abroad probably enhances the long-term competitiveness of some foreign smelters relative to the U.S.

Environmental Regulations

As in the copper industry, domestic primary lead producers are subject to the Environmental Protection Agency's (EPA) National Ambient Air Quality Standards (NAAQS) for SO_2 gasses emmitted by smelters. Because the sulfur content of the principal lead bearing minerals (e.g., galena, PbS) is much lower than that of copper bearing ores (e.g., chalcopyrite, CuFeS2), however, much less sulfur is normally oxidized for each unit of material processed by lead smelters. It has been estimated that a lead smelter with no installed SO_2 controls produces only as much SO_2 copper smelter of equal size that has achieved an 80 percent recovery rate. 20/

Lead smelters also have several economic advantages over copper smelters in the recovery of SO_2 Since 85 percent of the SO_2 produced in the lead smelting process are released during the initial, sintering phase of the operation, it is normally feasible to keep SO_2 offgasses from the sintering machine at sufficiently high concentrations to make the operation of a sulfuric acid plant efficient. Most of the principal primary lead smelters in the United States have the additional advantage of being located relatively near to large sulfuric acid consumer markets. 21/

For these reasons, SO_2 recovery in the primary lead industry is considered to be adequate to meet national environmental regulations. In recent years, the NAAQS for SO_2 has not been exceeded in the vicinity of any of the domestic primary smelters and refineries. In one case, this success has only been made possible by a special agreement with the Environmental Protection Agency that calls for scheduled smelter shutdowns during periods of unusual environmental

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19/ Mineral Facts and Problems. 1975. p. 605.

20/ Everest Consulting Assoc., Inc. and CRU Consultants, Inc. The International Competitiveness of the U.S. Non-ferrous Smelting Industry and the Clean Air Act. April 1982. p. 5-18.

21/ Ibid. p. 5-30.

sensitivity. Under current guidelines, this type of control will only be permissable through 1988, at which time the smelter will either have to be fitted with a new acid plant or be closed. 22/ Nevertheless, given the relatively low additional cost to the industry as a whole of sulfuric acid recovery, the Clean Air Act regulations governing SO_2 emissions are not generally considered to pose a major threat to the cost competitiveness of the primary lead industry. 23/

A much more serious problem, however, is posed by the regulations that have been promulgated for lead particulates. In 1978, the EPA established a level of 1.5 micrograms per cubic meter of air as the ambient standard that would have to be achieved in the vicinity of lead smelters and refineries. At the time, that standard was exceeded in the areas surrounding two of the three primary smelters in Missouri. The EPA subsequently approved Missouri's State Implementation Plan (SIP), which called for compliance with the standards by October 31, 1984.

A study produced by Charles River Associates, however, has concluded that full compliance with the NAAQS for lead cannot be achieved in the vicinity of the Missouri smelters. This is because the "background" levels of suspended lead particulants, derived primarily from vehicle emissions, are so high that the standard would be exceeded at anything less than 95 percent recovery of fugitive lead emissions from the smelter operations. Such a high level of recovery, according to the study, is not technologically feasible.

In apparent recognition of these difficulties, EPA has extended the date for full compliance with the NAAQS for lead to January 1, 1988. The total additional cost to the industry of achieving this standard was estimated to be around $.04 per pound, about one-third of which has already been incurred. 24/

Standards governing the permissable level of suspended lead particulates within lead producing and lead product plants have also been promulgated by the Occupational Safety and Health Administration (OSHA) (OSHA) of the Department of Labor. Recent studies indicated, however, that while costs would probably be less than $.01 per pound of lead

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22/ U.S. Bureau of Mines. Comments on CRS draft. July 10, 1984.

23/ Everest Consulting Assoc. Inc., and CRU Consultants, Inc. International Competitiveness. p. 5-30.

24/ U.S. Bureau of Mines. Mineral Commodity Profiles - 1983. Lead. p. 11.

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produced, the installation of all existing technology would be insufficient to achieve the required level of 50 micrograms per cubic meter. 25/

Finally, in March 1983, an OSHA standard setting a limit of 50 milligrams of lead per 100 grams of blood for all employees in the lead industry became effective. According to the regulations, any worker whose blood-lead level reaches that maximum must be removed to a leadfree environment until his or her blood-lead level falls back to 40 milligrams per 100 grams of blood. The industry has subsequently stated that these restrictions could leave as much as 30 percent of some plants' workforce on Medical Removal Protection (MRP) at any one time, causing serious losses in productivity. 26/ To date, however, the average loss due to MRP regulations for the industry as a whole has been much lower than this estimate. 27/

The government-imposed environmental standards for foreign lead producers are, in general, less stringent than those with which the U.S. industry must comply. Among the three major competitors in the Western Hemisphere, Canadian regulations probably match U.S. levels most closely (see table III:4). Direct comparisons of the effective level of pollution control, however, are complicated by somewhat different regulatory strategies and, in the case of Canada, by the relative autonomy of provincial authorities. In addition, data on actual compliance with their governments' regulations by foreign producers are, for the most part, unavailable.

25/ Charles River Associates, Inc. Economic and Environmental Analysis of the Current OSHA Lead Standard. CRA Project No. 536.60. 1981. p. 5-4.

26/ Ibid. p. 11.

27/ U.S. Bureau of Mines. Lead. Preprint from Bulletin 675. Mineral Facts and Problems. 1985 ed. p. 14.

Table III:4. Comparison of Government Standards for the Control of Lead Pollutants in Selected Countries

	Maximum Lead in Plant Air (mg/m3)	Maximum Lead in Emissions (ug/m3)	Maximum Lead in Blood (ug/dl)	Maximum Lead Particulants Outside Plant (ug/m3)
U.S.	.05[a]	variable[b]	50	1.5
Canada	.15[a]	4-6[c]	70	none
Mexico	.15[a]	none	none	none
Peru	.20[a]	none	60	none

(a) Twenty-four hour average.

(b) Determined in State Implementation Plan (SIP) so as to comply with the NAAOS.

(c) Varies among provinces.

Source: International Lead and Zinc Study Group. Environmental and Health Controls on Lead. January 1982.

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IV. ZINC*

A. Introduction

The domestic zinc industry has been affected by declining competitiveness at the mine, smelter, and refinery stages of production. The key factor in the competitive position of zinc mines is geological in nature. Just as with the copper and lead industries, the productivity of the U.S. zinc labor force appears to be greater than that found among foreign producers. Again, U.S. zinc deposits are relatively low grade and contain significantly less byproducts than found in deposits in Canada, Mexico, and Peru. This geological advantage provides foreign zinc producers with sufficient additional revenues not only to tolerate low zinc prices but also to offset their lower worker productivity. As with copper and lead, exchange rates and internal inflation rates of foreign producers are negatively affecting relative U.S. production costs, and domestic smelters are being adversely affected by the growth of overseas capacity. Compliance with environmental regulations seems to have proved less burdensome to the zinc industry than to other U.S. primary metal producers, and does not appear to constitute a major competitive disadvantage for U.S. producers.

B. Market Share and Current Economic Conditions

Slightly smaller than the lead industry, the domestic zinc industry ranks fifth among the major U.S. metals producers in terms of the annual market value of mine production. In the last two decades, however, its decline, in terms of both production and value-added, has been more evident than in either the copper, the lead, or the iron ore industry (see following chapter).

As can be seen in table IV:1 the share of total domestic zinc supply originating in U.S. mines fell considerably from the 1960s to the 1970s. The permanent closure of three historically important operations, two in Idaho and one in Pennsylvania, has probably prolonged this trend in the early 1980s. These losses, however, have been partially offset by the opening of two new mines, one in Tennessee and another in New York. 1/

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*Prepared by John G. Ellis, Research Assistant, Office of Senior Specialists.

The share of domestic supply accounted for by U.S. smelter and refinery production has fallen even more dramatically in the last decade. Since 1971, seven of the nine U.S. zinc smelters have experienced prolonged or permanent closure, while only one new plant has come onstream. Although three of the plants that were shut down have been reopened after extensive modification, domestic slab zinc production capacity in 1981 had fallen to 35 percent of its 1971 level. 2/

Table IV:1. Shares of Total Available Domestic Zinc Supply a/: 1956-60, 1966-70, 1976-80 (percent, in terms of metal content)

		1956-60	1966-70	1976-80
Ores and Concentrates:	U.S.	35	34	27
	Foreign	65	66	73
Slab Zinc:	U.S. Primary	70	66	36
	U.S. Secondary	15	17	22
	Imports	15	17	42

a/ "Total Available Domestic Supply" is defined as domestic primary and secondary slab zinc production plus slab imports. U.S. exports are included.

Source: U.S. Bureau of Mines. Mineral Yearbook [various issues].

Growing domestic secondary supplies have partially replaced declining primary zinc production. As is evident in table IV:1, however, imports of slab zinc have been by far the most rapidly increasing source of supply in the U.S. market. In the late 1970s, zinc imports accounted for over 40 percent of total available supply, as compared with only 15 percent in the late 1950s.

While zinc markets showed some signs of recovery in late 1983 and early 1984, leading to the reopening of two mines and one smelter that

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1/ U.S. Bureau of Mines. Minerals Yearbook, 1982. Vol. I, Metals and Minerals. 1983. pp. 895-896.

2/ Everest Consulting Assoc., Inc. and CRU Consultants, Inc. The International Competitiveness of the U.S. Non-Ferrous Smelting Industry and the Clean Air Act. April 1982. p. 6-12.

had been shut down during the recession, relatively high costs of production appear to present serious long-term problems for domestic zinc producers' international competitiveness. According to the U.S. Bureau of Mines' MAS data, the average break-even production cost for the U.S. industry in 1981 ($.46 per pound) was above the domestic producer price for zinc in both 1982 and 1983. By contrast, while many foreign producers have experienced sharply reduced profits in the last few years, most appear to have been able to meet their operating costs even at the depths of the recent recession (see tables IV:2 and VI:3).

Table IV:2. Industry Stocks and U.S. Producer Prices for Zinc, 1970-1984

	Producer Price (constant 1981 dollars)	Industry Stocks ('000 metric tons)
1970-79 (average)	.44	160
1980	.41	126
1981	.45	196
1982	.36	153
1983	.38	120
1984 (1st quarter)	.47	n.a.

Source: U.S. Bureau of Mines. Minerals and Materials (serial). April/May 1984.

Table IV:3. Estimated Total Costs for Producing Zinc Mines in 1981 (1981 dollars per pound of zinc recovered)

	U.S.	Canada	Peru	Mexico	All Foreign
Mine Operations	.26	.16	.22	.31	.20
Mill Operations	.10	.10	.10	.10	.10
Post Mill Processing	.20	.18	.17	.20	.18
Other Costs	.09	.17	.11	.15	.14
Total Operating Costs	.65	.61	.59	.75	.61
Taxes	.04	.02	.16	.10	.05
Byproduct Credits	.23	.32	.36	.77	.37
Net Operating Costs	.46	.31	.30	.09	.28
Total Costs	.58	.36	.35	.16	.33

Source: U.S. Bureau of Mines. Primary Lead and Zinc Availability--Market Economy Countries. Minerals Availability Program. IC 9026. 1985. p. 28.

Not surprisingly, given the continuous growth of imports in the last decade, important individual foreign suppliers all seem to enjoy substantial cost advantages over the domestic industry in the production of primary zinc. Average total production costs in Canada, which has been the source of over half the U.S. imports of both processed and unprocessed zinc materials in the last five years, were about 40 percent below average U.S. costs in 1981. Peru, which has supplied almost onefifth of U.S. imports of zinc ores and concentrates, appears to have had a smaller, but still significant cost advantage. With total costs at less than one-third and less than one-half the levels in the U.S. and in Canada, respectively, Mexico is generally considered to be the world's lowest cost producer. In the last several years, the completion of a number of "greenfield" and expansion projects has increased production capacity in the latter country by about 25 percent for mine output and over 50 percent for smelted, slab zinc. 3/ As a result, Mexican imports have recently taken an increasingly greater share of the U.S. market.

C. The Mining Sector

Labor and Productivity

As in the case of the lead industry, the combination of many different products in lead-zinc mine output makes it very difficult to quantify international differences in labor costs and productivity for a single metal like zinc. While wages and worker output are as important cost factors in this as in other mining industries, their impact on competitiveness can only be evaluated in terms of the relative profitability of the entire stream of production in a number of very different types of operations.

In the preliminary stages of production alone, the MAS data do indicate that U.S. zinc miners' productivity, as in the other metals industries, is substantially superior to productivity in the average foreign operation. Even though average domestic zinc ore grades range from one-third to one-half the foreign average and U.S. wages are double or triple the levels in competing developing countries, the total costs of mining and milling, in terms of contained metal as well as ore output, were below the averages in Mexico and Peru in 1981. Given its initial disadvantages, these results clearly reflect much greater efficiency in the U.S. industry's extraction, handling and processing of zinc ores. Only in the case of Canada, where a more skilled work force contributes to higher levels of productivity than prevail in Latin America, do higher zinc ore grades convert a cost disadvantage in terms of ore processed into an advantage (before byproduct credits) in terms of final metal output, relative to the U.S. (see table IV:4).

3/ U.S. Bureau of Mines. Minerals Yearbook. 1982. Vol. III, Area Reports: International. 1983. p. 630.

As will be seen in the next section, however, the rankings that might be derived from this comparison of the direct costs of mining operations may give little indication as to the ultimate competitiveness of individual industries. Since profitability is determined by the difference between unit costs and revenues, variations in the latter variable may, in fact, often be the deciding factor in determining overall market viability.

Table IV:4. Estimated 1981 Operating Costs for Producing Zinc Mines

	Mine		Mill		Total	
	Per Ton of Ore	Per Pound of Metal	Per ton of Ore	Per Pound of Metal	Per Ton of Ore	Per Pound of Metal
U.S.	14.40	.26	5.50	.10	36.10	.36
Canada	17.80	.16	9.80	.09	66.40	.25
Mexico	20.90	.31	6.90	.10	51.60	.41
Peru	24.00	.26	11.90	.13	61.30	.39

Source: U.S. Bureau of Mines. Minerals Availability Program. Unpublished data.

Ore Grades and Byproduct Credits

In a geologic sense, the U.S. zinc industry can be differentiated from its major foreign competitors along much the same lines as the lead industry. As was noted in the preceding chapter, a large part of world lead and zinc output is derived from deposits containing significant quantities of both lead and zinc. In the United States, on the other hand, over three-quarters of annual zinc production comes from mines in which lead output is of minor importance, both in terms of zinc producers' revenues and in terms of total U.S. lead production. 4/ Thus, even though about 20 percent of U.S. zinc supply is produced as a byproduct from the Missouri lead mines, it is much easier to distinguish between the two industries than is generally the case abroad.

Like the domestic lead industry, U.S. zinc producers also differ from their foreign counterparts in their heavy reliance on relatively low grade deposits. About 40 percent of annual U.S. production comes from the extensive, strata-bound deposits of eastern and central Tennessee which contain, on average, about 3 to 4 percent zinc. Higher grade massive sulfide deposits in New York, with average zinc

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4/ Minerals Yearbook. 1982. Vol. I. p. 904.

grades of around 9 percent, produce only about half as much zinc each year as the Tennessee mines. Finally, with the recent closure of several major western mines, domestic zinc production from high grade lead-zinc-silver replacement and vein deposits has fallen to about 5 percent of annual available supply. 5/

The Canadian lead-zinc industry's reserves situation is almost the inverse of the domestic industry's. Nearly 80 percent of Canada's annual output comes from copper-zinc or lead-zinc massive sulfide deposits with combined major metals ore grades of around 10 percent. As a result, the average ore grade of zinc is 7 percent for the entire Canadian industry, as opposed to only 3.3 percent in the U.S. The presence of significant quantities of lead and other co- or byproducts further enhances many Canadian producers' revenue earning capabilities relative to the zinc-only mines in the eastern U.S. (see table IV:5).

Table IV:5. Production Capacity and Average 1981 Ore Grades for Producing Zinc Mines

	Zinc Production Capacity ('000 tons)	Average Ore Grade		
		% Zinc	% Lead	Grams Silver/Ton
U.S.	4,140	3.28	0.14	2.7
Canada	17,129	6.29	2.90	54.7
Mexico	4,947	4.63	1.82	139.1
Peru	5,347	6.78	2.77	108.1

Source: U.S. Bureau of Mines. Minerals Availability Program. IC 9026. 1985. p. 26

Both the Mexican and Peruvian lead-zinc industries enjoy similar advantages over the U.S. in terms of the zinc content of ore. Of even greater importance in these countries, however, is the production of zinc from ore bodies that are heavily enriched with precious metals, particularly silver. The average Mexican and Peruvian zinc ore bodies contain 139 grams and 121 grams of silver per ton of ore, respectively, as compared with an average of less than 3 grams per ton in the United States (see table IV:5). A number of the largest zinc suppliers in Latin America are in fact classified as silver mines, with copper, lead and zinc considered by the operators to be byproducts. In these, as well as in the primarily lead-zinc operations, the additional revenues from precious metals sales often more than compensate for relatively lower levels of productivity than prevail in the North American industries. As may be seen in table IV:3, byproduct credits actually offset the entire pre-tax operating costs of Mexican zinc production. This is the principal factor that makes the latter country the world's "lowest cost" producer of zinc.

5/ Ibid. p. 904.

Undeveloped Deposits

While depletion and high costs have resulted in a significant reduction of U.S. zinc mining capacity in recent decades, several large, potentially profitable deposits have been identified that, if developed, might sustain or even lead to a resurgence of the industry during the remainder of this century. Of these, Cominco's Red Dog prospect in Alaska, a massive sulfide deposit, has advanced the furthest toward development. Containing 77 million tons of ore grading 17.1 percent zinc, 5 percent lead and about 75 grams of silver per ton of ore (see table IV:5 to compare with United States and foreign averages), Red Dog could become the world's largest zinc producer. Current plans envisage a start-up sometime in 1989. 6/ Also under consideration is a large zinc-copper-lead deposit at Crandon, Wisconsin. High development costs, low prices and an unfavorable state tax regime, however, will probably postpone initial production from this deposit until sometime in the 1990s. 7/

Inflation and Exchange Rate Fluctuations

As was seen in the preceding chapters, the difference between the U.S. CPI and the Canadian CPI converted to U.S. dollars between 1977 and 1983 has probably not been great enough to have a significant effect on the relative cost positions of the two countries' zinc industries. The tumultuous conditions prevailing in the Mexican and the Peruvian economies, on the other hand, may have resulted in rather rapid changes in competitiveness relative to the United States.

As is evident in table IV:6, the Peruvian inflation rate between 1977 and 1981 was much higher than the United States, Canadian, and even the Mexican rates. Unlike the Mexican peso, however, the Peruvian sol depreciated rapidly against the dollar throughout this period, so that Mexican and Peruvian prices converted to dollars advanced at about the same rate in the five year period before 1981. Because this rate was considerably higher than the U.S. CPI, Mexican and Peruvian costs of zinc production also tended to rise more rapidly than in the United States or Canada during this period.

Since 1981, the financial crises confronting the Mexican and Peruvian economies have been reflected in accelerating rates of inflation and currency depreciation. The rapid depreciation of the Mexican peso and other measures taken to restrict or increase the cost of imports have helped to push internal prices up at a much more rapid rate

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6/ Ibid. p. 897, and CRS inquiry of U.S. Bureau of Mines. June 4, 1984.

7/ Ibid. p. 897.

than has even prevailed in Peru. However, the net effect of that depreciation and inflation has been to lower the Mexican index of consumer prices converted to U.S. dollars by nearly 40 percent between 1981 and 1983, as compared with a little over 20 percent for Peru. Both these adjustments have probably tended to reduce dollar-denominated Mexican and Peruvian zinc production costs relative to those faced by the U.S. industry. This effect on the other hand, has probably been offset to a large extent by the rapidly increasing cost of imported materials, spare parts and other capital goods, upon which both countries' mining industries are heavily reliant.

D. The Zinc Smelting and Refining Industry

In the last decade, U.S. zinc smelting and refining capacity has nearly halved. A recent study commissioned by the American Mining Congress attributes this decline to four factors. 8/

First, because a number of U.S. plants were, in the past, tied to mines located in the continental interior, the reduction of mine capacity made it increasingly difficult to acquire competitively priced raw materials. The higher transportation costs of bringing such feeds from distant sources, combined with the U.S. tariff on such imports, was particularly important in raising these operations' costs above competitive levels.

Exacerbating this problem was a sharp increase in the demand for and the price of internationally traded zinc ores and concentrates. Between 1970 and 1980, non-U.S., western world primary zinc smelting capacity increased by more than 20 percent, while total mine capacity remained at about the same level. Thus, whereas a substantial surplus of foreign ores and concentrates was available for processing in the U.S. in the 1960s, excess world smelting capacity now makes it much more difficult for the domestic industry to sustain smelter output at substantially higher levels than domestic mine output. The costs of competing for unprocessed feeds are particularly high, of course, for those firms that have no equity involvement in or other special trading relationship with foreign mines.

A third factor that contributed to the declining profitability of many zinc processing operations was the obsolescence of much U.S. plant. Because of their superior efficiency and because they produce a higher grade product, electrolytic smelting operations have been increasingly preferred by the industry in recent decades. In 1966, however, only five of the thirteen operating domestic plants, accounting for 44 percent of production capacity, employed this

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8/ Everest Consulting Assoc. and CRU Consultants. International Competitiveness. pp. 6-11 - 6-16.

technology. Two of those plants were the oldest of their kind in the world, having been constructed in 1915. In the 1970s, the domestic industry's two old electrolytic smelters and all but one of the then operating horizontal or vertical retort plants were retired. As a result, the electrolytic process now accounts for over 80 percent of the remaining domestic primary smelting capacity.

Finally, it is likely that the increasingly stringent national, state and local environmental regulations promulgated in the United States during the 1970s influenced domestic producers' decisions as to whether or not some of their aging plant could continue in operation. This was an important consideration with regard to the vertical and, especially, the horizontal retort smelters, from which it is very difficult to efficiently recover both zinc and sulfur pollutants. On the other hand, the relative ease with which emissions from electrolytic plants can be controlled has favored their continued operation. As will be seen in the next section, this efficiency also reduces the costs of environmental regulation to the domestic zinc smelting industry as it is now constituted.

Environmental Regulation

In general, environmental regulations are less burdensome to the zinc industry than to most of the other primary metals sectors because most domestic zinc-bearing ores contain fewer potentially toxic pollutants, in lower concentrations, than do most other base metal ores. On average, for example, domestic zinc ores and concentrates contain about 0.6 of a pound of sulfur per pound of zinc metal, or just a little over half the average sulfur content per pound of metals in domestic copper ores. 9/ The regulations that have been promulgated for lead emissions and suspended particulants also do not pose a signficant problem for smelters processing the low lead-content zinc ores of New Jersey, New York, and Tennessee (acccounting for about 75 percent of domestic capacity). The same cannot be said, of course, of the zinc that is produced as a co- or a byproduct from the Missouri lead mines or from the lead-zinc-silver operations in the western United States.

As in the lead industry, zinc operations also benefit from the relative simplicity of the smelting process. While pollutants are emitted during two or three stages of copper processing, for example, all SO_2 emissions in zinc smelting occur during the roasting of the concentrate feed. With polluting offgasses confined to one source, it is much easier to keep sulfur concentrations at relatively high levels. This, in turn, allows more efficient operation of associated sulfuric acid plants. 10/

9/ Ibid. p. 6-39.

10/ Ibid. p. 6-34.

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Table IV:6. Indexes of the Price of Zinc and of Consumer Prices Converted to U.S. Dollars in Zinc Producing Countries, 1977-1983.

			Canada			Mexico			Peru		
	Price of Zinc(a)	U.S. CPI	CPI	Exchange Rate (b)	$CPI (c)	CPI	Exchange Rate (b)	$CPI (c)	CPI	Exchange Rate (b)	$CPI (c)
1977	77	67	68	92	74	45	92	48	14	26	54
1978	70	72	74	100	74	52	93	56	21	39	54
1979	83	80	81	98	83	62	93	66	36	49	73
1980	84	91	89	101	88	78	94	84	57	67	85
1981	100	100	100	100	100	100	100	100	100	100	100
1982	86	106	111	104	107	159	225	71	164	196	84
1983	93	109	117	104	113	384	482	62	246	313	79

(a) Based on U.S. High Grade, cents per pound, delivered.

(b) Local currency per U.S. dollar. A rising index means depreciation of the local currency and apprecia of the dollar.

(c) The index of foreign consumer prices converted to dollars is obtained by dividing the foreign CPI by t exchange rate in local currency per dollar and multiplying by 100.

Source: International Monetary Fund. International Financial Statistics. U.S. Bureau of Mines. Mineral Commodity Summaries.

Finally, compliance with environmental regulations has been facilitated by the closure of obsolete horizontal and vertical retort smelters and by the resulting increased reliance on electrolytic processes. Engineers have generally agreed that it would probably not have been technically feasible to meet current SO_2 National Ambient Air Quality Standards (NAAQS) at the old horizontal retort plants, none of which are in operation today. The efficiency with which emissions from the modern electrolytic smelters can be controlled, on the other hand, has made it possible for the industry to achieve an average level of sulfur recovery well in excess of 95 percent in recent years. In addition, the electrolytic plants recover three times as much zinc contained in dust and fumes as was recovered at the horizontal retort plants. Since the percentage of zinc that is recovered per ton of ore processed has increased, this efficiency has been as important from an economic as from a regulatory standpoint. 11/

As is the case in the other metals industries, it is difficult to assess the impact of U.S. environmental regulations on the international cost competitiveness of the zinc industry. Foreign smelting operations almost certainly do not achieve the same levels of SO_2 recovery, for example, as prevail in the United States. It has been estimated that, in Canada, about 85 percent of the emissions are captured, and average recovery levels in Mexico and Peru are probably even lower. 12/ On the other hand, to the extent that foreign producers do comply with their governments' emissions standards for lead (see table III:4), their costs may tend to exceed costs to those domestic operations where the low lead content of ore presents only a minimal pollution control problem. In any case, the relative efficiency with which U.S. zinc smelters are able to produce and market sulfuric acid makes it unlikely that this particular factor constitutes a major competitive disadvantage vis-a-vis the major foreign competitors.

11/ U.S. Bureau of Mines. Mineral Commodity Profiles, 1983--Zinc. p. 13.

12/ Everest Consulting Assoc. and CRU Consultants. International Competitiveness. p. 6-34.

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V. IRON ORE*

A. Introduction

Perhaps more than the other segments of the metals mining industry discussed here, the iron ore industry, because of its ties to steel production, has been sharply affected by structural changes in downstream capacity levels and technology. Historically, most domestic iron ore production has been institutionally integrated with blast furnaces and steel mills, thereby insulating the markets for domestic iron ore from ore imports more than is the case for the other non-ferrous metals. However, this did not protect the iron ore mines from experiencing acute economic circumstances during the 1981-82 recession, reflecting the reduced competitiveness of U.S. steel producers, the growth of steel imports, and the shift to new steel production methods.

Like the nonferrous metals, U.S. iron ore producers have seen their comparative attractiveness as sources of primary iron adversely affected by the impact of inflation rates and exchange rate adjustments on the production costs of some overseas producers. As with copper, rising productivity has been insufficient to offset the competitive burden on the iron and steel producer of relying upon lower grade domestic ores, particularly in conjunction with high U.S. wage rates. Lower grade ores have raised energy costs per ton of production. Finally, although not a key factor in the competitive picture for the nonferrous metals, reductions in international transport costs have helped increase the competitiveness of foreign iron ores in U.S. markets.

B. The Mining Sector

The iron ore mining industry contributes about the same amount to GNP as the copper mining industry. In 1982, the value added of the U.S. iron ore industry was about $0.8 billion, as compared with $0.7 billion for copper mining. 1/

1/ U.S. Bureau of the Census. Census of Mineral Industries. 1982. General Summary, MIC82-S-1. pp. 1-2. Value added is a measure of output similar to gross product originating. The latest year for which such data are available for mining industries is 1982.

*Prepared by John G. Ellis, Research Assistant, Office of Senior Specialists.

This comparison, however, understates iron ore's absolute and relative importance in the U.S. economy. Value-added by steel mills and iron and steel foundries exceeded $20 billion in 1982, about eleven times the value added in comparable copper processing operations -- $1.8 billion. 2/ These totals are not directly comparable since steel, unlike refined copper, is an alloyed material with much more value added during the production process. Nevertheless, the performance of the downstream industries dependent on iron ore clearly has much greater significance for the overall performance of the U.S. economy than is true for the downstream copper industries. While this chapter will not directly address the competitiveness of the steel industry, the significance of its reliance on iron ore should be kept in mind.

Ore Grades and Product Characteristics

The bulk of world production has historically come from enriched sedimentary iron ore deposits, in which the weathering of low grade hematite (Fe_2O_3) or magnetite (Fe_3O_4) primary ore bodies has left a material that contains from 50 to 60 percent natural iron. Since they were first mined in the 1850s, the Lake Superior iron ore districts in the United States have yielded over 3 billion tons of this type of ore (annual domestic iron ore production has averaged around 75 million tons from 1975-81). While large reserves of enriched sedimentary ores still exist offshore (e.g., in Quebec, Canada), the major deposits of this type in the United States were largely exhausted by the early 1960s. 3/

The other principal source of high grade iron ore is metamorphosed deposits that have been upgraded by subsurface hydrothermal enrichment. The iron content of some of these ore bodies approaches 70 percent, the theoretical limit for pure hematite (based on that mineral's chemical composition). Reserves of nearly 20 billion tons of hydrothermally enriched ore with an average grade approaching 65 percent have been identified, for example, in Brazil's Carajas district. The Venezuelan iron ore industry also draws on substantial reserves of this type of deposit.

Having depleted its reserves of high grade ore, the U.S. industry is now almost entirely dependent on large sedimentary deposits of unenriched, low grade "taconite" ore. While the worldwide grade average for these types of deposits is between 25 and 35 percent, the iron

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2/ U.S. Bureau of the Census. Annual Survey of Manufactures. M83 (AS)-1. 1983. pp. 1-18, 1-19.

3/ The discussion on iron ore resources is based on information contained in the U.S. Geological Survey Professional Paper 820. Probst, Donald A. and Walden Pratt, eds. United States Mineral Resources, 1973. pp. 291-306.

content of ores mined in the U.S. in the early 1980s has averaged only about 22 percent. Today, the industry must remove and process nearly twice as much ore per ton of contained iron as was necessary in the 1940s, when enriched sedimentary deposits still accounted for a large portion of U.S. output (see figure V:1).

Because, all other factors being equal, more energy, manpower, and capital are required to extract the same amount of usable iron from lower grade ores, the natural iron content of an iron ore deposit is probably the most important determinant of its relative cost structure. Since the average Brazilian or Venezuelan iron mining operation must process less than half as much material to obtain equal amounts of marketable product, its gross operating costs are likely to be lower than in the U.S. taconite industry.

The Competitive Implications of Different Processing Technologies

The above *prima facie* generalization only applies, however, to the extent that iron ore producers all employ the same or similar processing techniques and offer a substantially undifferentiated product in the marketplace. But, because of geographical variations in deposit types and in other factor endowments, these conditions are not always met. In order to make valid comparisons of the net costs of different iron ore sources, therefore, it is sometimes necessary to examine the individual qualities of different products and how those qualities affect market value.

The efficiency with which iron ore minerals are converted to pig iron is determined by two principal characteristics of the blast furnace charge. First, because impurities in the ore must be oxidized in order to be separated from the natural iron, the chemical composition of the iron ore feed directly affects energy consumption. Second, because the hot furnace gasses do not disperse evenly if the charge is too fine-grained, too lumpy, or if it melts too rapidly, the physical properties of the iron ore determine both energy use and blast furnace productivity. 4/

The iron ore products that have historically been charged to blast furnaces can be classified into two groups, differing principally in their physical characteristics. Until the 1960s, the primary feed was "lump ore", a material that is crushed, concentrated and sorted according to particle size, but whose essential chemical and mechanical properties remain unchanged from the natural state.
Today, on the other hand, 85 to 90 percent of most blast furnace

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4/ Strassburger, Julius H. Blast Furnace - Theory and Practice, Vol. I. New York: Gordon and Breach Science Publishers, 1969. pp. 81-95.

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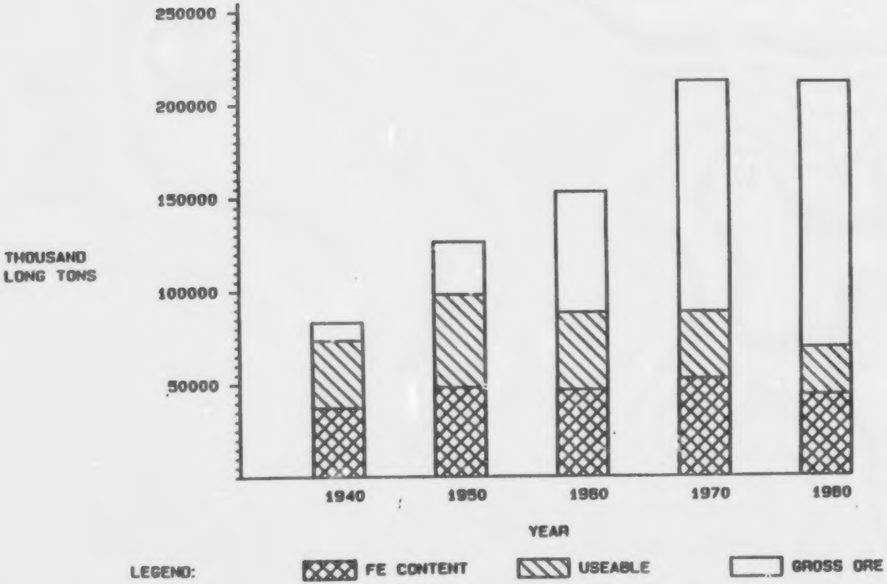
FIGURE V:I: NATURAL IRON CONTENT AND USEABLE PRODUCT FROM IRON ORE MINED IN THE U.S., 1940–1980



SOURCE: BUREAU OF MINES. MINERALS YEARBOOK.

charges consist of iron ore "agglomerates", products that are formed by partially melting and fusing finely ground lump ore feeds into particles of uniform size and physical structure. 5/

The costs of agglomeration are high, ranging from 25 to nearly 100 percent of the initial costs of mining and ore preparation. 6/ Because the metallic iron is so finely disseminated in taconite, for example, the ore must be ground to the consistency of talcum powder before it can be concentrated by magnetic separation. Upon completion of this upgrading process, however, the product is much too fine-grained to be directly charged to the blast furnace. In order to market their product, therefore, taconite producers have no alternative but to agglomerate the material into iron ore pellets. This process involves rolling the concentrate with water to form 2 to 3 centimeter "green balls", which must then be fired to harden and preserve their structure.

Even though they have been forced to adopt a much more costly processing technology, however, U.S. pellet producers appear to have flourished in the last two decades. Pellet production's share of total U.S. iron ore output has grown from 16 percent in 1950 to 62 percent in 1970 and 92 percent in 1980. By the late 1970s, taconite pellets accounted for about 70 percent of the average domestic blast furnace burden. 7/

The discovery that pellets perform much more efficiently than lump ore in the blast furnace burden was the principal reason for the domestic taconite industry's past success. Production tests have shown that, because of the hardness of the individual agglomerated particles and because of the permeability of the feed itself, blast furnace energy consumption may fall by one third and productivity may double by switching from a predominantly lump ore to an agglomerate charge. These savings are so substantial that they more than offset the additional direct costs of the agglomeration process. 8/

5/ Meyer, Kurt. Pelletizing of Iron Ores. Dusseldorf, Springer-Verlag, 1980. p. 256.

6/ Manners, Gerald. The Changing World Market for Iron Ore - 1950-1980. Washington, Resources for the Future, 1971. pp. 151-153.

7/ U.S. Bureau of Mines. Mineral Commodity Profiles, 1983 - Iron Ore. p. 4.

8/ Kakela, Peter J. Iron ore: Energy, Labor, and Capital Changes with Technology, Science, vol. 202, no. 4373, 15 December 1978. pp. 1151-1157.

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If the only alternative to iron ore pellets were still lump ore, then the higher costs of taconite pellet production would be of little concern to domestic steel producers. However, like their U.S. counterparts, most foreign producers have also vastly improved blast furnace efficiency in the last few decades by increasing the proportion of agglomerates in the furnace charge. By 1976, agglomerates accounted for approximately 83 percent, 82 percent and 79 percent, respectively, of total iron ore charged to blast furnaces in Japan, West Germany and the United Kingdom. The comparable proportion for the U.S. industry was 87 percent. 9/

Thus, the principal difference between modern steel makers' iron ore consumption patterns is not in the proportion of agglomerates charged to the blast furnace, but in the choice of which agglomeration technology to employ. While pelletization is the only feasible technique for agglomerating U.S. taconite ores, foreign producers with access to high grade deposits have often preferred the other major technology, the sintering process. Sinter is formed by partially melting a combination of finely-ground, high grade iron ore with coke breeze. The resulting sinter cake is crushed and sorted into uniformly sized particles for charging to the furnace. Partly because the entire process is considerably less expensive than pelletization of low grade ores, sinter now accounts for 70 percent and 80 percent respectively of the average Japanese and West European blast furnace burden. 10/

At present, most experts seem to agree that neither pellets nor sinter have demonstrated a clear superiority as a blast furnace feed. Since both products are formed from high grade concentrates, they contain comparable amounts of natural iron (62 to 65 percent). As with pellets, individual sinter particles are hard enough to resist early break-down in the furnace, while the permeability of the sinter charge itself permits even dispersal of the furnace gasses. There are also no systematic differences in the amount of impurities contained in the two products. In terms of their productive efficiency in the blast furnace, then, pellets and sinter appear to be an essentially undifferentiated product. 11/

As a result, while the comparative costs of lump ore and agglomerates are a deceptive measure of their competitiveness in the market, the costs of pelletization and sintering operations shown in

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9/ Meyer. p. 256.

10/ Meyer, p. 256.

11/ See Meyer, op. cit., pp. 253-254, and International Iron and Steel Institute, Committee on Technology, Presentation of technical papers, Vol. I. Production of Pellets and Sintered Ore and Their Use in the Blast Furnace. Rio de Janeiro, April 1979. pp. 181-191.

table V:1 may indicate the real net cost advantage or disadvantage of reliance on the different sources of iron ore. Because less processing expenditure is required per ton of product, the direct costs of agglomerating operations based on high grade Brazilian deposits are low by North American standards. And since the output from such operations performs as well as any other iron ore product in the blast furnace, those lower iron ore production costs may translate into lower net costs of the steel making operation as a whole, particularly in relation to the net costs of the operations whose primary source of iron is taconite pellets. Thus, the U.S. industry's increasing reliance on taconite pellets in the last two decades has led to an increase in raw material costs relative to foreign producers that has not, as will be subsequently seen, been offset by superior productivity.

C. Market Share and Current Economic Conditions

As in the major nonferrous industries, the 1981-82 economic recession triggered the most serious contraction in the iron ore industry since the Great Depression. With capacity utilization at around 40 percent, domestic production in 1982 was less than half its 1979 peak. Industry employment in 1983 stood at just over one-third the 1979 level, having continued to fall in spite of a marginal increase in output from 1982. 12/

Despite these difficulties, domestic iron ore price quotations have remained remarkably stable in recent years. 13/ Throughout the 1981-82 recession, the average unit value of domestic iron ore products continued to increase in nominal terms, although that represented a small constant dollar decline in 1982. Published producer prices for Lake Superior iron ore pellets showed a little more weakness, falling by 3 to 10 percent in real terms during the 1979-83 period (see table V:2). This decline was modest, however, compared with the 68 percent, 60 percent, 37 percent and 15 percent drops in the real domestic prices of lead, molybdenum, copper and zinc, respectively, over the same five-year period.

Some of the credit for this relative price stability must be attributed to the substantial, rapid reductions in output undertaken

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12/ U.S. Bureau of Mines. Mineral Commodity Summaries, 1984. p. 76

13/ Because most U.S. iron ore production is controlled by integrated steel companies, very little trade is subject to open market prices. As a result, most U.S. price quotations are principally based on estimates of the value of iron ore shipments, based on approximate production, handling and shipping costs. Such estimates, however, are subject to variations in different firms' accounting practices and, in the aggregate, should only be viewed as approximations of current value.

Table V:1. Comparative Representative Iron Ore Production Costs, 1980 (U.S. dollars per long ton)

	U.S.			Canada			Brazil		
	Lump	Sinter a/	Pellets	Lump	Sinter a/	Pellets	Lump	Sinter a/	Pellet
Labor	6.65	8.73	9.15	5.30	7.38	7.30	1.15	3.23	1.90
Energy	4.30	8.47	6.25	2.10	6.27	3.15	.80	4.97	4.10
Raw Mats Misc.	5.70	5.93	8.65	5.85	6.08	9.00	3.80	4.03	8.00
Handling	3.50	3.53	3.50	3.60	3.60	3.60	6.50	6.50	6.50
Total Op. Costs	20.15	26.63	27.55	16.85	23.23	23.05	12.25	18.73	20.55
Deprec. & Amor. Interest	1.85	2.53	2.75	2.10	2.78	3.20	2.10	2.78	3.00
Taxes	2.75	--	4.20	2.00	--	2.75	1.75	--	1.85
Total Cost (f.o.b.)[b]	24.75	29.16	34.50	20.90	26.11	29.00	15.60	21.51	25.35
Transp. (delivered Chicago)[c]	5.70	5.70	5.70	6.95	6.95	6.95	13.00	13.00	13.00
Total Costs	30.45	34.86	40.20	27.85	33.06	35.95	28.60	34.51	38.35

(a) Sinter costs based on adjusted 1970 cost data (source: Julius Strassburger, ed., Blast Furnace - Theo and Practice, New York, Gordon and Breach Science Publishers, 1969, pp. 271-2). Agglomeration is assumed to take place in the U.S.

(b) F.o.b. nearest shipping ports: Escanaba in U.S., Sept-Isles in Canada and Tubarao in Brazil.

(c) Via Mississippi River barges for Brazil, including reloading from ocean transports.

Source: Barnett, Donald F. The Iron Ore Industry: Problems and Prospects. Ottawa: Department of Energy, Mines, and Resources, 1982.

by U.S. producers in the early 1980s. With supplies restricted, both producer and consumer stocks continually declined throughout this recessionary period, easing the downward pressure on prices.

Probably of equal or greater importance, however, has been the insulation of the United States from international iron ore markets. For more than a decade, the average prices paid by foreign steel producers for iron ore products have been considerably lower than those paid by their domestic counterparts. Largely because of reliance on lower value-added products, the average iron ore costs per ton of steel produced in Japan, for example, were 26 percent less than the U.S. average in 1980 (see table V:3).

The differences between domestic and international prices, however, are not simply a reflection of different product mixes. In the late 1970s, low cost foreign producers began to offer iron ore pellets at prices as much as 25 percent below the price reported by domestic suppliers. Since then, the constant dollar prices of these products have declined by over 18 percent, 8 to 15 percent more than the decline of U.S. prices. In 1983, it was reported that Brazilian pellets were being sold in Chicago and at east coast U.S. ports at prices ranging from 38 to 43 percent below the delivered cost of domestically produced pellets (see table V:2). 14/

In general, these price differentials seem to reflect significant production cost advantages enjoyed by foreign producers across the entire range of iron ore products. Canadian iron ore pellets, for example, can apparently be delivered at Chicago steel plants at a cost that is 15 percent lower than the delivered cost of the same product originating in the northern Minnesota iron range (see table V:1). Despite the added costs of ocean transportation, Brazilian pellets enjoy almost the same cost advantage in that market.

It seems likely that, in a non-integrated system relying on open market purchases, imports from foreign sources might capture a larger share of the U.S. market for ores and pellets. In fact, however, imports have fallen a bit more rapidly than has domestic mine production in the last few years. Since 1970, foreign producers' share of total domestic supply of iron-bearing materials has fallen from 20 percent in 1970 to 10 percent in 1983 (see table V:4).

The failure of iron ore imports to penetrate and their actual loss of share in the U.S. supply picture despite evidence of a cost advantage is primarily a result of the ownership structure of the U.S. iron ore and steel industries. About 90 percent of domestic mine capacity is owned or controlled, through various partnerships, by the major integrated steel producers themselves. In the late

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14/ U.S. Bureau of Mines. Mineral Commodity Profiles, 1983 - Iron Ore. p. 3.

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Table V:2. Average Prices for Iron, 1960-83 (dollars per long ton of iron contained in ore or product)

	Aggregate (a) F.O.B. U.S. Mines		Domestic Pellets, C.I.F. U.S. Ports		Brazilian Pellets, C.I.F. U.S. Ports	
	Current Dollars	Constant Dollars	Current Dollars	Constant Dollars	Current Dollars	Constant Dollars
1960-69	16.72	43.20	n.a.	n.a.	n.a.	n.a.
1970-79	32.17	49.39	n.a.	n.a.	n.a.	n.a.
1979	52.30	62.27	67.80	80.96	48.18-49.82	57.53-59-49
1980	58.24	63.62	73.70	80.60	46.15-52.31	50.49-57.23
1981	63.84	63.84	80.50	80.50	n.a.	n.a.
1982	65.30	61.60	80.50-86.90	75.93-81.95	n.a.	n.a.
1983	n.a.	n.a.	80.50-86.90	72.85-78.64	46.15-53.85	41.77-48.73

(a) The price for aggregate iron ore products is calculated from producers' statements of the average iron content and the value of the different forms of usable ore at the mine plant.

Sources: U.S. Bureau of Mines. Mineral Commodity Profiles, 1983-Iron Ore. p. 8.
U.S. Bureau of Mines. Minerals Yearbook. [various years].

Table V:3. Estimated Operating Costs of Cold-Rolled Steel Sheet, Japan versus the U.S. (dollars per ton of product)

		Labor	Iron Ore	Scrap	Energy	Other	Total
1958	U.S.	43	15	7	25	24	114
	Japan	21	22	9	39	37	128
1964	U.S.	44	17	7	23	26	117
	Japan	17	22	3	30	30	102
1972	U.S.	57	23	5	35	35	155
	Japan	23	20	-	35	35	113
1980	U.S.	135	58	14	91	76	374
	Japan	64	46	-	100	76	286

Source: Barnett, Donald F. and Louis Schorsch. Steel: Upheaval in a Basic Industry. 1983. p. 64.

1970s, these firms invested approximately $1.7 billion in new iron ore and pellet producing plant, expanding capacity by over one-third between 1975 and 1978 alone. 15/ Given this commitment, steel industry management has signalled its intent to absorb this added output, even though this could involve continuing financial losses. In recent years, these losses for some firms have equalled or, in a few cases, exceeded the receipts from iron ore purchases. But since the alternative would be to write off some very large capital investments, which might involve substantial after-tax losses, the steel-makers appear to be very reluctant to shift to other sources of iron.

As is evident from table V:4, however, domestic iron ore operations do not seem to have gained as a result of the decision to rely upon domestic sources. Over several decades, the major integrated steel producers have lost a growing portion of their market to specialized, "mini-mills". This has been of considerable significance to the iron ore industry because the mini-mills rely exclusively on electric furnace steelmaking technology, for which iron and steel scrap rather than primary iron ore products is the sole furnace charge. In contrast, the amount of scrap that may be charged to basic-oxygen furnaces (BOF), which currently account for nearly 60 percent of domestic steelmaking capacity, is normally limited to 25 to 30 percent of the total charge. 16/ As the latter technology has been replaced by electric furnace production, therefore, the demand for iron ore products relative to scrap has declined. As a result, domestic iron ore producers' share of the total supply of iron-bearing raw materials to the U.S. steel industry has declined, despite the relative lack of reliance upon what may well be lower real cost foreign operations.

Inflation and Exchange Rate Fluctuations

The cost comparisons shown in table V:1 reflect the economic conditions prevailing in 1980. In the last several years, however, the worldwide economic recession, the international debt crisis and other dramatic economic events may have changed those conditions considerably. As can also be seen in the copper, lead and zinc industries, many Third World iron ore producing countries have been wracked by rapidly accelerating inflation rates, which have tended to drive production costs up more rapidly than in the U.S. Some of those countries' monetary authorities, however, have attempted to reduce

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15/ Steelmakers' Excess Ore Capacity Hindering the Industry's Recovery. Wall Street Journal. August 29, 1983. p. 15.

16/ U.S. Bureau of Mines. Mineral Commodity Profiles, 1983 - Iron Ore. p. 8.

Table V:4. Quantities and Shares of Total Available Domestic Supply of Iron-Bearing Raw Materials (a), 1960-83 (thousand long tons of usable product and percent)

	Usable Iron Ore (b)			Iron & Steel Scrap		Total Supply	
	Mine Output	Imports	Exports	New Supply	Exports	Domestic Origin (c)	Foreign Origin (d)
1960: Quantity	88,777	34,585	5,236	58,685	6,420	153,882	34,745
Share	47%	18%	3%	31%	3%	82%	18%
1970: Quantity	89,760	44,876	5,492	77,431	9,029	176,220	45,145
Share	41%	20%	2%	35%	4%	80%	20%
1980: Quantity	69,613	25,058	5,689	74,251	9,971	153,835	25,578
Share	39%	14%	3%	42%	6%	86%	14%
1981: Quantity	73,174	28,328	5,546	76,108	5,728	155,010	28,824
Share	40%	15%	3%	42%	3%	85%	15%
1982: Quantity	35,433	14,501	3,178	49,215	6,075	90,723	14,919
Share	34%	14%	3%	47%	6%	86%	14%
1983: Quantity	38,000	11,000	3,300	54,879	6,250	99,129	11,535
Share	35%	10%	3%	50%	6%	90%	10%

(a) "Total available supply" is defined to include all U.S. iron production plus imports. Iron and steel scrap is included on the premise that it competes both directly and indirectly with iron ore products.

(b) "Usable iron ore" comprises all iron ore products suitable for charge to the blast furnace, including direct shipping ores, concentrates, sinter and pellets. The actual iron content of these materials varies. However, the average content for all U.S. products has been as follows: 1960: 53%, 1970: 59%, 1980: 63%, 19811983: 64%.

(c) Total supply of domestic origin includes mine production of iron ore plus new supply and exports of iron and steel scrap.

(d) Total supply of foreign origin consists primarily of imports of iron ore products. Historically, U.S imports of iron and steel scrap have been negligible.

Source: U.S. Bureau of Mines. Minerals Yearbook [various years].

inflation and offset the resulting competitive losses by allowing their currencies to depreciate against the dollar. Such developments may at times have had almost as much influence on current performance as ore grades, productivity and the other structural forces that ultimately determine individual producers' long-term competitive outlook.

In table V:5, the net effects of changes in local price levels and exchange rates in Brazil, Canada and Venezuela are compared with changes in U.S. price levels between 1977 and 1983. All data are in index form. As in other chapters, the Consumer Price Index (CPI) is used to compare internal developments in the individual economies because consistent time series data on actual production costs are not available on an international basis.

Table V:5 shows that Canadian inflation, while matching the U.S. rate in the 1977 to 1980 period, has outpaced U.S. inflation since 1980. When both price levels are expressed in terms of the same currency, however, it is evident that this differential has been reduced somewhat by the modest depreciation of the Canadian dollar against the U.S. dollar in 1982 and 1983.

While Venezuelan inflation exceeded the U.S. rate over the entire 1977-83 period, the most significant divergence also occured in the last three to four years. Unlike the Canadian situation, however, the Venezuelan bolivar retained its 1977 value against the dollar through the first quarter of 1983, and had only depreciated by less than one percent by the end of that year. As a result, the Venezuelan CPI, when converted to U.S. dollars, rose by 14 percentage points more than the U.S. CPI between 1980 and 1983. This differential may represent a significant decline in the Venezuelan iron ore industry's cost competitiveness relative to the U.S.

Because of the turmoil afflicting the Brazilian national economy, shifts in the short-term factors affecting U.S. competitiveness with that country have been much more volatile. Averaging over 50 percent between 1977 and 1980, inflation rose to over 100 percent in 1981 and over 200 percent in 1983. The inevitable uncertainties of attempting to predict short-term developments in such a destabilized economy have resulted in numerous miscalculations and in a more rapidly fluctuating relationship between the U.S. CPI and the Brazilian CPI expressed in terms of U.S. dollars. It should be noted, however, that Brazilian prices over the 1977-83 period, when converted to dollars, did not deviate very much on average from their 1980 level. The U.S. CPI, on the other hand, rose by over 60 percent during the same period. To the extent that changes in the respective countries' iron ore production costs have reflected this difference in dollar-denominated rates of price inflation (leaving aside for the moment any structural changes in productivity or in relative costs of the various factors of production), Brazilian producers' competitive position relative to the U.S. industry has probably improved substantially over the course of the last eight or nine years.

Table V:5. Indexes of the Price of Iron Ore and of Consumer Prices (CPI) Converted to U.S. Dollars in Iron Ore Producing Countries, 1977-1983.

	Price of Iron Ore	U.S. CPI	Canada			Brazil			Venezuela		
			CPI	Exchange Rate (a)	$CPI (b)	CPI	Exchange Rate (a)	$CPI (b)	CPI	Exchange Rate (a)	$CPI (b
1977	74	74	76	91	84	26	27	95	68	100	68
1978	80	79	83	99	84	36	34	105	73	100	73
1979	90	88	91	97	94	55	51	107	82	100	82
1980	100	100	100	100	100	100	100	100	100	100	100
1981	110	110	112	99	113	206	177	116	116	100	116
1982	113	116	125	103	121	407	341	120	127	100	127
1983	n.a.	120	131	103	127	1302	1031	126	134	100	134

(a) Local currency per U.S. dollar. A rising index means depreciation of the local currency and appreciation of the dollar.

(b) The index of foreign consumer prices converted to dollars is obtained by dividing the foreign CPI by the exchange rate in local currency per U.S. dollar and multiplying by 100.

Sources: International Monetary Fund. International Financial Statistics. U.S. Bureau of Mines. Minerals Yearbook.

Labor Costs and Productivity

As in most of the other mining industries, labor is the single largest component of the U.S. iron ore industry's production costs. In the decade between 1972 and 1982, average wage rates grew from $4.41 to $12.98 per hour in nominal terms, equal to a constant dollar increase of 44 percent. More importantly, the ratio of additional benefits and compensation paid to domestic iron ore workers appears to have increased substantially in recent years. According to the Bureau of Labor Statistics, the ratio of total additional benefits to straight-time wages paid to all iron and steel workers grew from 47 percent to 70 percent between 1977 and 1982 alone. Similar additional compensation wage ratios probably apply in the iron ore sector, where the workers are for the most part also organized by the major steel industry unions. If so, domestic iron ore workers' total hourly compensation has grown by over 40 percent, in real terms, in just the last five years. Increased benefits and other non-wage costs would have accounted for about half of this growth (see table V:6).

As a result of this growth, beginning from initially high levels, U.S. wage costs are much higher than those of most major foreign competitors. In 1981, for example, total compensation to Canadian iron ore workers amounted to about $14 per hour (in 1981 U.S. dollars), $4 less than the equivalent U.S. cost. 17/

Data on developing country wages are much more scarce, and are almost always limited to straight-time rates. In 1977, the International Labor Organization reported earnings equivalent to about $6 per hour in the Venezuelan mining industry. 18/ This rate, which compares relatively well with the $7.10 straight-time U.S. wage in the same year, is high by most Third World standards, reflecting U.S. companies' previous ownership of the principal iron ore operations as well as the Venezuelan government's acknowledged emphasis on social as well as competitive goals in its current management decisions. In contrast, the average wage cost in the Brazilian iron ore industry has been reported to be around $4 per hour in 1983, or less than one-fifth the level of total compensation in the United States. Because of hyper-inflation in the Brazilian economy, which has averaged about 90 percent in recent years, Brazilian miners' real income has probably fallen by at least 30 percent in the last three years. 19/

17/ Energy Mines and Resources Canada - Minerals. The Canadian Mineral Industry Monthly Report. October 1983. p. 8.

18/ International Labor Organization. Statistical Yearbook, 1981. p. 561.

19/ CRS inquiry of U.S. Bureau of Mines. June 5, 1984.

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Table V:6. Average Hourly Wages and Total Compensation in the U.S. Iron Ore Industry, 1972-82.

	Straight-time current dollars	Wages constant 1972 dollars	Additional current dollars	Compensation constant 1972 dollars	Total current dollars	Compensation constant 1972 dollars
1972	4.41	4.41	n.a.	n.a.	n.a.	n.a
1977	7.10	5.11	3.36	2.42	10.46	7.52
1982	12.98	6.33	9.11	4.44	22.09	10.77

Source: Bureau of Labor Statistics. Office of Productivity and Technology. Unpublished data.

Of course, if there are substantial variations in productivity, wage rates themselves may bear little relationship to net labor costs. As in the other domestic mining industries, U.S. iron ore producers have traditionally relied on continuing increases in productivity to offset rising wages and to keep net costs at competitive levels. In recent years, however, the decline of domestic ore grades has for the most part frustrated these efforts. As is evident from table V:7, the industry has succeeded in sustaining the growth of crude ore processed per man-hour. But, because a ton of ore has contained less natural iron in each succeeding year, the output of usable ore declined from an average of 2.12 tons per man-hour in 1970-74 to an average of 2.01 in 1975-79.

Foreign iron ore workers' productivity in terms of usable product tends to be higher than in the U.S., primarily because they work much richer natural deposits. In 1981, for example, the Canadian industry produced two-thirds as much usable iron ore as in the U.S. with less than half the number of U.S. production workers. Brazilian productivity, based on some of the world's highest grade ore, is particularly remarkable; with almost exactly the same size workforce, Brazil's output was more than triple the U.S. total in 1981. Only in Venezuela, where, as already noted, employment decisions have been based on social as well as cost criteria, has productivity been near the U.S. level.

It appears, therefore, that the domestic iron ore industry's substantially higher wage rates are not offset by superior productivity. In fact, the data in table V:8 suggest that international wage cost differentials are augmented by the lower levels of U.S. output per production worker. The cost margin is most dramatic for Brazil, where much higher productivity and much lower wage rates combined to keep net labor costs per ton of product at less than one-tenth the U.S. level. But U.S. labor costs appear to be high even with respect

Table V:7. U.S. Iron Ore Labor Productivity, 1970-80

	Employment		Production		Productivity	
	Avg. No. Employees (thousand)	Total Hours Worked (thousand)	Crude Ore (thous. long tons)	Usable Ore (thous. long tons)	Crude Ore Per Hour Worked	Usable Ore Per Hour Worked
1972	14	35,600	187,600	75,100	5.27	2.11
1973	19	38,300	218,700	87,400	5.70	2.28
1974	20	39,100	217,200	83,900	5.55	2.14
1975	20	39,100	214,500	78,400	5.48	2.00
1976	20	39,200	224,100	79,300	5.72	2.02
1977	20	30,400	158,400	55,200	5.21	1.82
1978	21	39,700	234,400	81,100	5.91	2.05
1979	18	40,000	255,800	85,400	6.39	2.13
1980	18	34,100	212,100	69,600	6.22	2.04
1981	18	34,400	227,000	73,200	6.61	2.13
1982	9	17,200	106,600	35,400	6.18	2.05

Source: U.S. Bureau of Mines. Minerals Yearbook [various years].

to Canada, where wage rates are comparable to the domestic standards. Again, this is not attributable to the U.S. worker himself, who processes more crude ore than any other in the world, but to the very low grade of domestic reserves.

Energy

It has already been noted that, in theory, energy consumption tends to increase as ore grades decrease. The domestic industry's experience in the last few decades have certainly shown this to be the case in iron ore. Between 1954 and 1972, when the transformation from dependence on relatively high grade hematite to low grade taconite deposits was made, average U.S. energy consumption increased from 366 to 1,660 thousand British Thermal Units (Btus) per long ton of useable iron ore produced. 20/

The principal cause of this dramatic increase in energy-intensity was the rapid development of domestic pelletizing capacity. In 1972, the agglomerating process alone was estimated to account for over 44 percent of the total energy consumed in producing taconite pellets

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20/ Gelb, Bernard A. and Jeffrey Pliskin. Energy Use in Mining: Patterns and Prospects. Cambridge, Massachusetts, Ballinger Publishing Company, 1979. pp. 33-34.

Table V:8. International Comparisons of Iron Ore Productivity and Estimated Labor Costs, 1981.

	Production Workers	Total Man-Hours (thous.)	Estimated Payroll (thous. $)	Useable Product (th. long tons)	Product Per Man-Hour	Payroll Per Employee	Payroll Cost Per Ton
U.S.	18,100	34,000	630,700 (b)	73,174	2.13	34,850	8.62
Canada	7,900	16,300	226,600	48,768	2.99	28,680	4.65
Brazil	9,000	18,700 (a)	74,900 (b)	96,314	5.15	8,320	.78
Venezuela	3,200	6,700 (a)	53,200 (b)	15,286	2.28	16,630	3.48

(a) Estimate assuming full employment, a forty-hour week and a fifty-two week year.

(b) Based on estimates of total hourly compensation of $18 for the U.S., $8 for Venezuela and $4 for Brazil.

Sources: U.S. Bureau of Labor Statistics. Unpublished data.
International Labor Organization. 1981 Statistical Yearbook.
Energy Mines and Resources Canada-Minerals. The Canadian Minerals Industry Monthly Report. October 1983.

see table V:9). Since the early 1970s, the improvement of heat recuperation technologies has reduced these costs by about 25 percent, to around 650 thousand Btus per ton. 21/

The sintering process is even more energy-intensive than pelletizing. With the sinter strand itself accounting for about 2 million Btus per ton of product, the total energy consumption for agglomerating an ore concentrate like the product represented in table V:9 would, theoretically, be at least 33 percent higher than pellet consumption.

In practice, however, sinter production is usually based on high grade natural ores, which require little of the energy used in mining, crushing and concentrating U.S. taconites. This may save more than 500 thousand Btus from the pre-agglomeration mining and processing stages production. 22/ Thus, total energy consumption for a sinter produced from a typical Brazilian ore, for example, probably exceeds energy consumption during taconite pelletization by only 15 to 20 percent.

Much of the potential energy savings from the use of high grade ores, on the other hand, are lost if pelletization is the chosen agglomeration technique. This is true, in the first place, because both high and low grade ores must be ground extremely fine to be pelletized. The grinding process, which is highly energy-intensive, accounts for a substantial portion of the energy consumption for

Table V:9. Estimated Energy Requirements in the Production of Taconite Pellets, 1972

	Thousand Btus per long ton	Percent
Mining	210	10.1
Crushing	100	4.8
Concentration	750	36.1
Agglomeration	920	44.2
Miscellaneous	100	4.8
Total	2080	100.0

Source: Gelb, Bernard A. and Jeffrey Pliskin. Energy Use in Mining. 1979.

21/ U.S. Bureau of Mines. Mineral Commodity Profiles, 1983 - Iron Ore. p. 10.

22/ Gelb and Pliskin, pp. 36-37, and Donald F. Barnett. The Iron Ore Industry: Probl;ems and Prospects. [Unpublished]. pp. 8, 12.

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"concentration" listed in table V:9. Energy consumption during the pelletization of high grade materials is also increased because an endothermic reaction occurs during the firing of hematite, the principal iron mineral in such ores. As a result, the total energy requirements for pelletizing high grade hematite ores may exceed the requirements for taconite by 200 to 300 thousand Btus per ton of product. 23/

In either case, however, the energy savings that result from the use of an agglomerated product in the blast furnace more than offset the additional consumption during the production of those materials. Between 1954 and 1972, the coke rate in domestic blast furnaces fell from .873 to .608 tons of coke per ton of pig iron produced. Since this difference amounts to about 4 million Btus per ton of iron ore charged to blast furnace, net energy consumption for the entire steelmaking process was reduced by about 20 percent as a result of the switch from lump ore to agglomerated feeds. 24/

An important factor affecting energy costs is the type of fuel that can be efficiently used in the various iron ore processing stages. The availability of low cost natural gases, for example, was instrumental in the development of the U.S. and Canadian pellet industries. On the other hand, the availability of low cost coking coal in Western Europe has favored the establishment of sintering capacity in that region. In the future, the relative scarcity of both these fuel sources may inhibit the development of a low cost agglomerating industry in Brazil. 25/

These factors are apparent in the comparative total energy costs shown in table V:1. U.S. energy costs in all three types of operations exceed the levels prevailing in most other producing countries. The principal cause of this disadvantage is again the very low grade of domestic iron ores, which raises the industry's mining and concentrating costs per ton of useable product well above the international average. This factor is of particular importance, of course, in comparing domestic and Brazilian energy consumption.

Transportation

Depending on the source and the destination, transportation costs can account for as much as 40 percent of the delivered price of iron ore. As a result, individual producers' competitiveness in certain

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23/ U.S. Bureau of Mines. Mineral Commodity Profiles, 1983 - Iron Ore. p. 10.

24/ See Gelb and Pliskin, p. 42, and Kakela, p. 1154.

25/ Meyer. p. 13.

markets is often determined by their proximity and by the particular forms of transportation available to ship their product from the mine to the steel plant site.

Historically, the high costs of long-distance bulk haulage made it difficult for most suppliers to compete in relatively distant markets. In 1950, less than 20 percent of world iron ore consumption was involved in international trade, more than half of which was represented by Swedish and French exports to neighboring Western European steel industries. 26/

In recent years, however, the relative costs of different short- and long-distance transportation systems have changed considerably. Most importantly, despite tremendous increases in energy costs, average charges for seaborne iron ore shipments have actually declined in constant-dollar terms over the last two decades. On the other hand, the rise in most inland transportation costs, while not dramatic, has been steady. As a result, the ratio of ocean freight to Great Lakes bulk carrier costs, for example, declined from about 1-to-2 in 1962 to 1-to-4 in 1982 (see table V:10).

The principal factor that has restrained the growth of transportation costs on both ocean and inland waterway routes has been the increasing size of iron ore carriers. Since the mid-1960s, the average cargo carried on the Great Lakes has nearly doubled in size, from 15,000 to 28,000 tons. The largest of the vessels currently in service, with capacities of around 60,000 tons, are estimated to have reduced transportation costs by as much as 50 percent. 27/

Such economies of scale have been even greater in the ocean trade, where average cargoes are currently in the 70,000 to 80,000 ton range and where the number of 100,000 to 200,000 ton carriers has been steadily increasing. Some of the larger ports in Europe and Japan, which can accomodate cargoes of as much as 250,000 tons, have achieved savings equal to 30 to 40 percent of current average shipping costs. 28/ U.S. importers have not shared these latter benefits, however, because no domestic ports are equipped to handle more than 65,000 tons. While this increases the cost of U.S. imports, insulating domestic iron ore producers from foreign competition to a certain degree, it also reduces foreign steel makers' raw materials costs relative to their U.S. counterparts.

26/ Manners. p. 173.

27/ U.S. Bureau of Mines. Mineral Commodity Profiles, 1983 - Iron Ore. p. 10.

28/ Ibid. p. 10.

Table V:10. Representative North American Iron Ore Transportation Costs, 1962-82 (cents per ton-mile)

	1962		1982
	Current dollars	1982 dollars	1982 dollars
Ocean Freight	0.1	0.3	0.2
Great Lake Freight	0.2	0.6	0.8
Rail Freight	1.3	4.0	4.0-7.0

Sources: Manners. The Changing World Market for Iron Ore, 1950-1980: An Economic Geography. Baltimore, John Hopkins Press, 1971, and U.S. Bureau of Mines, Mineral Commodity Profiles, 1983. Iron Ore. p. 10.

With ocean freight costs continuing to decline relative to inland transportation costs, the international steel industries have drawn on increasingly more distant sources of iron ore. Since 1950, the average iron ore ocean shipment has increased from about 2,000 to well over 5,000 miles. 29/

Continuing to rely primarily on North American supplies, U.S. producers have for the most part not participated in this expansion of long-distance iron ore trade. 30/ Nevertheless, transportation costs appear to have fallen enough to make imported iron ore products from low cost Latin American, African and Australian sources competitive in most inland markets. The additional costs of shipping Brazilian pellets to U.S. consumers in Chicago and Pittsburg, for example, did not offset the initial production cost advantage at the Brazilian plant in 1980. Canadian products have been delivered in the U.S. at even lower net costs (see table V:11).

29/ Manners. p. 173.

30/ Some U.S. steel companies' equity involvement in and partial reliance on Liberian and (before their nationalization in 1975) Venezuelan iron ore mines have been important exceptions to the general historical pattern of U.S. self-reliance. With the increasing need to reduce costs, cheap Brazilian imports also began to make substantial inroads into the U.S. market in 1982 and 1983.

Table V-11. Representative Transportation Costs and Estimated Total Delivered Cost of Iron Ore Pellets in Key U.S. Markets, 1980 (1980 dollars per long ton)

Market	Cost Item	Cost, Lake Superior Sources	Costs, Canadian Sources	Costs, Brazilian Sources
Chicago:	F.o.b. cost, shipping port	34.50	29.00	25.35
	Ocean or Lake Freight	5.70	6.95	6.00[a]
	Inland Transportation	--	--	5.00[b]
	C.i.f. cost, delivered	40.20	35.95	36.35
Pittsburg:	F.o.b. cost, shipping port	34.50	29.00	25.35
	Ocean or Lake Freight	6.90[c]	5.75[c]	8.80[d]
	Inland Transportation	7.75[e]	7.75[e]	11.50[f]
	C.i.f. cost, delivered	49.15	42.50	45.65

(a) Delivered at Gulf of Mexico ports.

(b) Mississippi barge transportation, including reloading from ocean-going carrier to barge.

(c) Delivered at Lake Erie ports.

(d) Delivered at East Coast ports.

(e) Rail shipment costs from Lake Erie ports to Pittsburg.

(f) Rail shipment costs from East Coast ports to Pittsburg.

Sources: Barnett, D.F. The Iron Ore Industry: Problems and Prospects. Ottawa, 1982.
U.S. Bureau of Mines, Minerals Yearbook, 1980.

VI. MOLYBDENUM*

A. Introduction

The U.S. molybdenum industry is, in terms of physical resources, the world's most important. Currently, the United States is the world's largest producer, a net exporter, and possessor of approximately half of the of the world's identified resources. Nonetheless, domestic molybdenum has encountered extended mine and plant closings. This suffering is a reflection of the recent economic recession, overexpansion of world and domestic capacity, and continued foreign byproduct output of molybdenum which is not responsive to the market price for molybdenum. The U.S. primary producer, however, is critically affected by the world market price. As a consequence, the future outlook for U.S. producers can be likened to that of Saudi Arabia in crude oil. Despite superior domestic resources, world overcapacity and inelastic foreign output have relegated the United States to a "swing" producer that must curtail production in periods of surplus, and increase output at times of excess demand.

B. Market Share and Current Economic Conditions

Molybdenum is not classified as a "major" metal because it is not a principal raw material from which specific metal products are formed. But in terms of value of output, reflecting its high unit price, it ranks among the important U.S. metal industries. At $3.15 per pound, molybdenum was eighty times the value of iron ore. 1/ Even though U.S. lead and zinc output are also many times greater than molybdenum output on a volume basis, the value of U.S. molybdenum production is in most years twice the value of U.S. lead and U.S. zinc production.

In the last thirty years, molybdenum has become an important alloying element in steel, to which it lends strength, durability and corrosion resistence in hostile environments. By comparison to the consumption of the "common" metals, the amount of molybdenum required to maximize these qualities is small; in "alloy steel", its primary end-use market, molybdenum often accounts for less than one

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1/ Based on the value of the iron content of ore or pellets.

*Prepared by John G. Ellis, Research Assistant, Office of Senior Specialists.

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percent of the final product's total weight. 2/ In 1982, U.S. steelmakers consumed less than 13 thousand metric tons of molybdenum while producing a total of about 9,400 thousand metric tons of alloy steel. By comparison, U.S. consumption of iron ore for all uses in 1982 was about 40,587 thousand metric tons.

The molybdenum industry has in recent years ranked as the third largest U.S. metals industry in terms of the total value of production. This reflects domestic producers' importance in the international supply picture, accounting for 53 percent of world mine output between 1976 and 1980 (see table VI:1). Molybdenum is now the only metallic mineral for which the U.S. is still a major net exporter.

Table VI:1. Average U.S. and World Mine Production, U.S. Exports and Imports of Molybdenum -- 1956-60, 1966-70, and 1976-80. (million pounds of contained molybdenum)

	1956-1960	1966-1970	1976-1980
World production	72.76	137.12	218.74
U.S. production:			
quantity	55.72	97.04	132.42
percent of world production	77	71	61
U.S. exports:			
quantity	21.16	23.81	36.1
percent of world production	29	17	17
U.S. imports	5.6	.25	2.18

Source: U.S. Bureau of Mines. Minerals Yearbook [various years].

The domestic molybdenum industry has been as severely affected by the recent economic recession as the "major" metals industries. AMAX, Inc., the world's largest molybdenum producer with 45 percent of total world production between 1978 and 1982, suffered large after-tax financial losses for the first time in its history in both 1982 and 1983. In response, both of its primary molybdenum mines in the U.S., as well as its large mine in Canada, were shut down from late 1982 through 1983. In 1983, it also took a write-off of $155 million on a large new deposit in Colorado that had been under development since the late 1970s. 3/

2/ AMAX, Inc. Securities and Exchange Commission Form 10-K. December 31, 1983. pp. 3-4.

3/ AMAX 10-K. 1983. p. 5.

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In 1982, employment in the segment of the U.S. industry for which molybdenum is the primary commercial product (referred to hereafter as the "primary producers") fell to less than 25 percent of the peak 1980 workforce (see table VI:2). Increased employment in 1983 resulted primarily from the opening of two new mines, in New Mexico and in Idaho, rather than from the reopening of the older, shut-down operations in Colorado. In early 1984, AMAX did recall over 770 workers in order to resume partial production at its two Colorado operations. The company indicated, however, that it had found it necessary to renew production only because stocks were no longer adequate to fill existing sales contracts, not because changed market conditions promised improvements in profitability. Both mines operated at only about 50 percent capacity throughout 1984, and were closed for two months in mid-1985 owing to low prices and worldwide inventory overhangs. 4/ Even with the renewed hiring, primary producers employed only slightly over half as many workers in 1984 as had been on the job in 1980.

Table VI:2. Employment and Unemployment in U.S. Primary Molybdenum Mines, 1977-84.

	Total Number of Workers	Percent of 1980 Workforce Employed
1977	4,300	-
1978	4,500	-
1979	4,800	-
1980	6,300	100%
1981	5,500	87
1982	1,500	24
1983	2,500	40
1984	3,600 e/	57

(e) - Estimated.

Source: U.S. Bureau of Mines. Mineral Commodity Summaries [various years].

The depressed molybdenum market in the early 1980s is the current manifestation of the extreme cyclical market fluctuations that have prevailed since the mid-1970s. In the last decade, the rapid growth of steel production led most analysts to forecast future molybdenum supply shortages. 5/ This, together with a short-term reaction to

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4/ Moly on the Rebound. Mining, Journal, April 19, 1985, p. 277; and Amax will Idle Two Moly Mines. American Metal Market, June 6, 1985. p. 1.

5/ Production Rise, Newcomers Seen as a Market Threat. American Metal Market. Molybdenum Supplement. July 20, 1984. p. 4A.

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Canadian labor strikes in 1979, produced rapid price increases. Between 1975 and 1980, the domestic producer price jumped by over 160 percent in real terms (using the implicit GNP deflator to discount for inflation) (see table VI:3).

Table VI:3. U.S. Producer Price of Molybdenum, 1975-84.
(dollars per pound of contained molybdenum)

Year	Producer Prices	
	Nominal	1975 Dollars
1975	2.62	2.62
1976	3.45	3.28
1977	4.01	3.60
1978	4.95	4.14
1979	7.50	5.77
1980	9.70	6.84
1981	8.50	5.47
1982	4.00	2.43
1983	4.00	2.34
1984 p/	3.65	2.06

(p) - Based on preliminary data.

Source: U.S. Bureau of Mines. Mineral Commodity Summaries [various years].

Seeking to take advantage of this situation, most U.S. and foreign producers undertook in the late 1970s to increase output as rapidly as possible. U.S. production increased by nine percent and five percent respectively in 1979 and 1980, even though strikes in the copper industry reduced byproduct molybdenum output significantly in 1980. The absolute growth of U.S. production accounted for nearly half the increase of total market economy world output. Because foreign producers had initially accounted for only about one-quarter of total output, however, their proportional growth was nearly double the U.S. rate in 1979 and 1980 (see table VI:4).

Unfortunately, molybdenum demand began to weaken just as these new supplies were entering the market. Structural economic changes in the industrialized countries, spurred by the second oil crisis in 1979, brought a rapid reduction in steel industry output after 1980. Table VI:5 shows that by 1983, U.S. molybdenum consumption had fallen to less than half the 1979 level (world consumption declined by 27 percent during the same period).

Thus, while world molybdenum production fell slightly short of consumption in four of the five years between 1975 and 1979, the 1980 supply was more than 20 percent greater than demand. As a result, total U.S. molybdenum stocks almost doubled in 1980, rising to 88 percent of domestic consumption. By 1982, U.S. stocks were equivalent to 62 percent of annual world consumption. In the face of this market overhang, real prices declined precipitously; the U.S. producer price in 1983 was 11 percent below the 1975 level and 66 percent below the 1980 peak (see table VI:3).

The failure of molybdenum producers to reduce molybdenum output to match declining demand in the 1980s is attributable to a number of factors. The importance of byproduct molybdenum production in the overall supply picture, however, is probably the dominant cause. In the U.S., about one-third of annual molybdenum production is normally produced as a byproduct from porphyry copper mines. This type of production also accounts for over half of Canadian output, and with the exception of one other primary mine in Mexico, accounts for all other non-communist foreign molybdenum production. In the western world, then, byproduct molybdenum has recently been supplying more than two-thirds of the market.

Although byproduct molybdenum sales are very important in the molybdenum market, they normally account for only a small portion of the total revenues of the copper operations from which they originate. Once a molybdenum recovery circuit is established at a copper mine, the marginal cost of sustaining production is very small in relation to the operation's total costs. 6/ Thus, byproduct molybdenum production is very likely to continue as long as copper production continues, regardless of conditions in the molybdenum market itself.

This inelasticity of supply response on the part of byproduct producers helps to explain the different behavior of the two segments of the molybdenum supply industry. While primary producers began to reduce output in response to weakening demand in 1980 and 1981, byproduct producers in the U.S. and abroad continued to offer molybdenum in an oversupplied market, at whatever price the market would offer, until depressed conditions in the copper market itself began to force the closure of copper-molybdenum mines. This did not occur until 1982 in the United States and Canada, or until 1983 in the other low-cost foreign copper industries (see table VI:4). Even after the recent numerous reductions in domestic copper output, however, utilization of molybdenum capacity in domestic byproduct operations remained well above capacity utilization in U.S. primary molybdenum mines in 1983 (see table VI:6). In 1983, byproduct production accounted for over 70 percent of total U.S. output -- a complete reversal of the historical distribution of market share between primary and and byproduct suppliers.

The lag between the time when decisions to invest in new molybdenum mine capacity was made and the time that new production has come

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6/ See, for example, U.S. Bureau of Mines. Mineral Facts and Problems. Bulletin 667. [1976]. p. 711.

on-stream has also contributed to conditions of oversupply in the 1980s. In addition to maximizing production at existing operations, molybdenum producers responded to the tight market conditions of the 1970s by exploring and developing new deposits. Because such expansion programs require up to five years to mature, many of these new sources of supply were not ready to produce on a commercial scale until the mid-1980s. Between 1980 and 1984, newly completed projects added nearly 90 million pounds of annual molybdenum production capacity -- increasing the western world total by more than 40 percent. Well over half of this new production potential was developed in the United States (see table VI:7). All of this occurred at a time when the conditions faced by the U.S. steel industry were deteriorating.

Table VI:4. Molybdenum Production, 1975-84 (million pounds of contained molybdenum)

	United States	Foreign				Total Western World
		Canada	Chile	Other	Total Foreign	
1975	108.7	32.5	23.4	2.0	57.9	166.6
1976	113.3	31.1	24.0	3.1	58.2	171.5
1977	121.9	33.1	24.0	3.1	60.2	182.1
1978	131.9	32.0	29.1	2.0	63.1	195.0
1979	143.1	20.9	29.1	3.1	53.1	196.2
1980	151.0	33.1	30.0	7.9	71.0	222.0
1981	136.9	32.0	34.0	7.1	73.1	210.0
1982	90.0	24.9	44.1	16.1	85.1	175.1
1983	33.1	19.0	34.0	15.0	68.0	101.1
1984	101.9	18.1	35.9	17.0	71.0	172.9

Source: Mining Journal (London). Mining Annual Review [various years].

Table VI:5. Molybdenum Consumption and Production, 1975-84 (million pounds of contained molybdenum)

	Consumption a/			World a/ Production
	U.S.	Non-U.S	Total	
1975	55.9	114.8	170.7	166.6
1976	57.1	120.3	177.4	171.5
1977	60.0	122.5	182.5	182.1
1978	70.1	129.9	200.0	195.0
1979	71.0	138.0	209.0	196.2
1980	60.0	129.0	189.0	222.0
1981	58.0	124.1	182.1	210.0

	Consumption a/			World a/ Production
	U.S.	Non-U.S.	Total	
1982	34.0	117.1	151.1	175.1
1983	30.0	110.0	140.0	101.1
1984	39.0	125.9	164.9	172.9

(a) Market economy countries only.
Source: Mining Journal (London). Mining Annual Review [various years].

Table VI:6. Estimated Capacity Utilization in U.S. Primary and Byproduct Molybdenum Mines, 1980-83. (Annual production as a percent of annual capacity)

Year	Primary Operations a/	Byproduct Operations b/	Total
1980	96	82	92
1981	80	87	82
1982	45	58	49
1983	9	47	21

(a) Annual capacity was estimated to be 110 million pounds in 1980 and 115 million pounds in 1981-1983.

(b) Annual capacity was estimated to be 55 million pounds in 1980-1983.

Source: U.S. Bureau of Mines. Minerals Yearbook. [various years]. Mining Annual Review (London). [various years].

By the time most of these operations were capable of full production, market conditions no longer justified the additional supply. At least five of the new mines listed in table VI:7 were closed by July 1985, reducing world capacity by some 32 million pounds. 7/ While the ability to produce a number of coproduct metals has not buffered primary producers from depressed molybdenum market conditions, some companies had acquired so much debt and sunk so much of their liquid assets into these new projects that they found it necessary to commence production at an operating loss in order to maintain cash

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7/ Moly on the Rebound. Mining Journal (London). April 19, 1985. pp. 265-266; and, Mount Pleasant Closure. June 7, 1985. p. 407.

flow. Thus, while low prices had in 1982 forced the closure of the historically dominant producers in Colorado, new U.S. production began at operations in Idaho and New Mexico in late 1983 and early 1984.

In the early 1980s, Canadian molybdenum production and capacity utilization in general followed the U.S. pattern. As of mid-1985, the primary operations have been shut down, four byproduct mines are closed, and at least one, the Gibraltar, was producing unprofitably at current prices. 8/ Because byproduct output accounts for a larger share of its total supply capability, net capacity utilization in the Canadian industry as a whole historically has been greater than in the United States. 9/

Table VI:7. Development of New and Expanded Molybdenum Production Capacity, 1980-84 (million pounds of annual capacity)

Year of Project Completion	Country	Mine	Source of Molybdenum	Project Type	New Capacity
1980	Peru	Cuajone	byproduct	new	4
1981	Canada	Highmont	byproduct	expansion	5
1981	Canada	Kitsault	primary	new	10
1981	Canada	Lornex	byproduct	expansion	2
1981	Mexico	Caridad	byproduct	new	6
1981	U.S.	Tonopah	primary	new	15
1982	Canada	Boss Mtn.	primary	expansion	1
1982	Canada	Gibraltar	byproduct	expansion	1
1982	Chile	Chuquicamata	byproduct	expansion	8
1983	Canada	Mt. Pleasant	byproduct	new	1
1984	U.S.	Goat Hill	primary	new	20
1984	U.S.	Thompson Ck.	primary	new	20
					93

Source: U.S. Bureau of Mines. Minerals Yearbook. Mining Journal. Mining Annual Review.

8/ Moly on the Rebound. Mining Journal (London). April 19, 1985. p. 266.

9/ Energy, Mines and Resources Canada - Minerals. Canadian Mineral Survey 1983. February 1984. p. 50.

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Because all other market economy countries' production comes from byproduct operations, molybdenum output outside the United States and Canada has remained at close to full capacity. This has largely reflected the conditions governing foreign copper production, including lower operating costs and Third World countries' need to reduce excessive national debt burdens (see copper chapter).

C. Comparative Production Costs

For many years the United States had only one primary molybdenum mine, the Climax mine in Colorado. Today there are three primary operations. Climax has been joined by the Henderson mine in Colorado; both are operated by AMAX Inc. In addition, there is the Questa mine in New Mexico operated by Molycorp, Inc. Given these few operations, cost data concerning primary operations is sparse. However, primary ore is quite lean with only about one-quarter of one percent molybdenum contained in the ore. The operations, compared to the more common base metals, are expensive and involve the removal and processing of large volumes of material for very little metal in return. It is estimated that typically it costs about $3.54 per pound of recovered molybdenum to produce a concentrate ready to be moved to the smelter. 10/ This includes mining, milling, taxes, and capital recovery.

In 1983 and 1984 the producer quotes for concentrates were listed at $3.12 and $3.84. This indicates how close recent prices have been to actual costs. This is in considerable contrast to conditions in the 1970s when the average annual price in (1983 dollars) ranged from around $5.00 per pound of contained molybdenum to over $10.00. 11/ Not surprisingly, Colorado output was drastically reduced in late 1982.

In contrast, the molybdenum found in copper ores is only one-tenth of that in the primary ores, averaging only .023 percent. Because a copper mine is normally expected to stand on its own economically, molybdenum production does not normally bear any of the costs of mining, milling and the initial concentrating of the ore. In addition, underutilized facilities in the copper circuit can often be easily applied to the separation and concentration of byproduct molybdenum. The additional manpower requirements are minimal. As a result, the incremental costs of byproduct molybdenum production are principally limited to the costs of the energy and materials used directly in the separation of molybdenum from the already partially concentrated copper circuit tailings. These costs may vary from

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10/ Unpublished data from the U.S. Bureau of Mines.

11/ U.S. Bureau of Mines. Minerals Yearbook 1984, p. 655 and Mineral Facts and Problems, 1985, p. 530.

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operation, to operation but on average they are probably well below the current price of molybdenum (under $3.00 per pound in October 1985). Thus, it is highly unlikely that market conditions would ever dictate shut-down of byproduct molybdenum production at a copper operation so long as copper production itself remained viable.

Clearly, the different structures of the two segments of the industry cause their production decisions to diverge. In molybdenum, where one company has historically supplied over two-thirds of U.S. production (and as much as one half of the world total), primary producers have exerted substantial control over market conditions. Knowing that their individual levels of output affect the prices they receive, these producers have an incentive to restrict supplies in a glutted market. Individual copper-molybdenum producers, on the other hand, are "price takers" in the molybdenum market (i.e., their production decisions are unlikely to significantly affect prices). 12/ Because these producers also face increasingly intense competitive pressure in the copper market, current decisions to reduce supply may result in permanent losses of future market share. Given such tactical considerations, as well as the low incremental cost of molybdenum production from copper operations that have continued to be open, byproduct molybdenum supplies tend to react much more inelastically to changed market conditions than is the case for primary molybdenum operations. This has certainly been the observed behavior in the early 1980s (see tables VI:4 and VI:6).

Since foreign byproduct molybdenum producers operate in the same competitive environment, their response to depressed copper and molybdenum market conditions is similar to that of U.S. copper producers. 13/ However, because their copper production costs tend to be lower than in the United States, many offshore producers' profitability has not been as severely damaged under these conditions (see the previous copper chapter). Some of the most profitable foreign copper producers are also among the largest sources of byproduct molybdenum. In the early 1980s, Chile surpassed Canada to become the western world's second largest molybdenum supplier (see table VI:4). Since Codelco-Chile's average copper production costs are well below the U.S. average, it has remained profitable throughout the recent economic recession. This profitability would be expected to be maintained even if a major realignment of the peso/dollar exchange rate were to take place. As a result, these and other low cost foreign byproduct supplies will probably continue to be available regardless of conditions in the molybdenum market.

12/ Slade, Margaret. Dominant Firm Pricing and Byproduct Supply - the Structure of the U.S. Molybdenum Industry. University of British Columbia. July 1981. p. 17.

13/ In fact, as was discussed in the chapter on copper, foreign copper is probably supplied more inelastically than U.S. copper.

D. Outlook

In terms of competitive durability, non-communist world (NCW) molybdenum production appears to be arrayed in three tiers. The low cost position of foreign byproduct supplies, originating primarily in the Latin American copper industries, probably assures them a constant or perhaps growing share of the world molybdenum market. Despite higher cost North American copper producers' current economic difficulties, it is likely that U.S. and Canadian byproduct supplies will be the second tier settling at a stable, albeit lower, level of molybdenum output. Finally, it appears that U.S. and Canadian primary operations will be forced into the position of third tier "swing" producers. If the market is to be balanced, they will have to limit their sales to that portion of demand left unsatisfied by inelastic byproduct supply.

Given current demand expectations, this conclusion has very unfortunate ramifications for the primary molybdenum industry. In 1984, non-communist world molybdenum consumption was expected to be about 160 million pounds, an increase of 20 percent over 1983, but still less than 80 percent of the 1979 peak. At projected rates of growth, NCW consumption will be only 180 million pounds in 1990, compared with 193 million pounds in 1979. 14/

In 1983, byproduct suppliers worldwide produced over 80 million pounds of molybdenum. Codelco-Chile's output rose from 34 million pounds in 1983 to almost 36 million pounds in 1984. If conditions in the copper market improve, new private sector investments in that country could add another 15 million annual pounds of capacity in the current decade. 15/ Thus, if Peruvian output is constant, Latin American molybdenum production may be some 50 to 65 million pounds per year by 1990 -- equivalent to between 28 percent and 36 percent of anticipated NCW demand. Given depressed copper market conditions, the most likely level of output is probably in the lower part of this range.

Because of their high cost position relative to offshore competitors, the North American copper industries' will probably not be able to maintain their historical share of byproduct molybdenum production. At peak output in 1981, U.S. and Canadian copper operations produced about 60 million pounds. This was reduced by about one-third by 1983.

14/ The 1990 projection is based on an estimated average growth in demand of 2 percent per year from the 160 million pounds of molybdenum that are expected to be consumed in 1984. See, Moly Surplus Will Hang Over Market Through '84, and Modest Recovery in World Use Seen, in American Metal Market. Molybdenum Supplement. July 20, 1984. p. 10A.

15/ Chilean Outlook Good. American Metal Market. Molybdenum Supplement. July 20, 1984. p. 13A, and, Moly on the Rebound. Mining Journal. April 19, 1985.

At present, it seems unlikely that market conditions will warrant a widespread reopening of shut-down copper capacity during the remainder of the 1980s. If so, North American byproduct molybdenum sales will probably level off at around 40 million pounds per year by 1990.

Thus, total byproduct output can be expected to reach about 90 million pounds in 1990, supplying about half of anticipated NCW demand in that year. Since this supply will probably be available regardless of the conditions prevailing in the molybdenum market itself, primary production will have to be limited to the remaining 90 million pounds of demand.

As a result of recent mine openings and expansions, however, estimated U.S. and Canadian primary molybdenum annual production capacity is now over 180 million pounds, 86 percent of which is located in the United States. Clearly, current conditions of oversupply will be unlikely to disappear unless substantial reductions in primary production capacity occur. Even if the entire Canadian primary molybdenum industry were to be shut down for the remainder of the 1980s, the U.S. primary industry's 1984 annual production potential (at approximately 155 million pounds per year) would apparently still exceed anticipated 1990 NCW demand by about 65 million pounds, or by over one-third of existing domestic capacity.

Thus, despite U.S. producers' putative ability to supply nearly all of world demand at low cost, the industry is actually likely to experience a major contraction in the current decade. This contraction may further be affected by the structural changes currently underway in the mining industry as a whole. A number of major oil companies, such as Standard Oil of Indiana, Atlantic Richfield, and Penzoil, are in the process of divesting their mining subsidiaries, including copper and molybdenum operations. These divestitures could amount to simple changes in ownership. Some observers feel, however, that they could portend future closures among new owners unable to use a rich corporate parent to offset losses in the face of stagnant demand, and the continued availability of inelastic foreign and domestic byproduct supplies. 16/

16/ Moly on the Rebound. Mining Journal. April 19, 1985. p. 267.

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VII. ALUMINUM*

A. Introduction

In the previous chapters we have examined five domestic metal mining industries based on the mining and processing of domestic ores and concentrates. The raw pigs, ingots, or slabs of metal they produce as the initial metal product from the smelter furnaces are further refined and turned into a variety of semi-fabricated forms -- sheets, tubing, wire, bars, and so forth. These are then used in the manufacturing sector or sometimes as final products, e.g., copper wire for carrying electric current.

However, in addition to this group there are two important metal industries whose development was not primarily dependent upon domestic production of ores and concentrates. These are aluminum and the various kinds of ferro-alloys, excluding ferro-molybdenum. An examination of the competitive position of the more important U.S. metals industries is not complete without including them. Aluminum has the largest tonnage of domestic consumption among the non-ferrous metals. The ferro-alloying elements are relatively small in tonnage but are prominent members of the so-called "strategic and critical materials" group that generates so much concern in the context of national security. The status of the aluminum industry is reviewed in this section and ferro-alloys in the following one.

B. Evolution of the U.S. Industry

Aluminum, despite being the most abundant metallic element in the earth's crust, was not even identified as an element until the early 1800's and was not producible in commercial quantities for several decades after that. Eventually, electrolytic processes were developed simultaneously in the United States and France that made it possible for the metal to become available in quantity. Today, aluminum has become one of our most familiar and important metals. Nonetheless, the world still relies upon a single source material -- bauxite -- as the most suitable form from which the extractive process can produce refined metal. Bauxite is a natural product of the weathering of surface rocks that are high in aluminum content. It is a material rich in minerals containing aluminum oxides (alumina) and relatively low in silica. Since weathering is an essential step in this in-situ process of concentration, the more tropical areas of the world with their heavy rainfalls have become the major suppliers of bauxite (see table VII:1).

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*The initial drafts of this section were prepared by Pamela F. Woods of the staff of the International Trade Commission while on detail to the Congressional Research Service. The final draft was prepared by John J. Schanz, Jr., Senior Specialist , Energy and Natural Resources, and Karen L. Hendrixson, Research Assistant, Office of Senior Specialists.

Table VII:1. World Bauxite Reserve Base and Aluminum Production, by country, 1984 (thousand metric tons)

Country	Reserves	Aluminum Production e/
Guinea	5,900	--
Australia	4,600	758
Brazil	2,900	412
Jamaica	2,000	--
India	1,200	270
U.S.	40	4,099
Norway	--	761
West Germany	--	750
France	--	342
Canada	--	1,200
USSR e/	300	2,100
All Other	6,220	4,829
World Total	23,200	15,521

-- = none or negligible

e/ = estimated

Sources: U.S. Bureau of Mines. Mineral Commodity Summaries. 1984. p. 19.
U.S. Bureau of Mines. Minerals Yearbook. Vol. I. 1984. p. 105.

The Aluminum Company of America (Alcoa) was the only domestic producer of bauxite, alumina, and aluminum from 1886 to 1940. But the sharply expanded additional capacity to meet the need for aluminum during World War II led to the appearance of two additional private firms by 1946. By the 1950s, three foreign firms were located in Canada, France, and Switzerland. Today, Australia, West Germany, USSR, and Norway are found among the major world producers, and Brazil is about to join this group. (See table VII:1). The United States, except for 1934-40 when Germany led, has remained the world's leading producer of primary aluminum. As the U.S. industry grew, it soon became apparent that the modest supplies of bauxite in Arkansas were insufficient to supply the industry's needs. This domestic inadequacy continues. Despite the presence of vast quantities of other kinds of high alumina clays and rocks in the United States, these are less suitable for processing.

In effect, how the United States and world aluminum industry appeared and evolved reflects the nature of the production process. More specifically, the U.S. industry emerged at the very beginning as a highly concentrated and vertically integrated operation in contrast to the more common sequence in which integration is the last stage of industrial development. Even after many years of growth of new capacity, six firms still held approximately 60 percent of the western world's capacity in 1982. For the domestic aluminum industry the process begins customarily with the offshore mining of bauxite and ends in the United States at smelters located in the vicinity of large power sources needed for the energy-intensive electrolytic refining process. Transportation economies would seem to suggest that shipping alumina from the mine would be cheaper than moving the bulkier bauxite. However, the U.S. firms, preferring processing to be under domestic control, located their original alumina plants inside U.S. borders, most frequently at a coastal transfer point where the material in transit would have to be transferred from ocean-going carriers to inland systems in any case.

This locational pattern remained intact for many years but began to change drastically in the last two decades. The U.S. reliance on foreign supplies continues, mainly from the Caribbean, Africa, and South America. By 1983, domestic bauxite was the source of less than one percent of U.S. supply. But total U.S. self-sufficiency in the production and consumption of alumina and refined aluminum is no longer true. Domestically produced alumina now shares the smelter market with imported alumina on a fifty-fifty basis. Even though the United States remains the leading producer of primary aluminum in the world, it now supplies only 80 percent of the U.S. consumption of new metal. The trend for the future is found in the announced plans by domestic firms that they are no longer planning any future additions to domestic smelter capacity. Future capacity will all be built abroad.

As new smelter capacity appeared throughout the world, the structure of the industry changed from its original pattern of a few, fully integrated, private firms. In essence, the aluminum industry was an oligopoly from the start, with the behavior typical of a market where one encounters relatively few firms producing a homogeneous product. The new smelting capacity has added to the number of sellers in the marketplace, but more importantly, among them are governmental or quasi-governmental entities. These firms, as noted previously in the discussion of the other metal commodities, want to supply domestic needs, to earn foreign exchange from exports, to satisfy a desire to own and to operate their own resource industries, and to create and maintain jobs. Today, 35 percent of world primary aluminum capacity is linked directly or indirectly to governments. 1/

Concurrently, many bauxite suppliers have or would like to develop a capability to convert their bauxite to alumina. They are quite naturally desirous of capturing more of the value-added in the processing chain through this move. In 1983, 60 percent of world bauxite production was processed to alumina in the country-of-origin. As a consequence, those smelting countries without adequate indigenous bauxite reserves had to begin importing alumina instead of bauxite. The United States is one of them. While the bauxite producers may also be attracted to producing aluminum metal, this is a much more ambitious goal which most are not able to achieve at this time.

U.S. producers, who had been historically able to enjoy an administered price structure that could be relied upon to cover, most of the time, their long-term costs plus an attractive return on investment, found the recession of the early 1980s an unfamiliar situation. In the economic downturn they were no longer able to remain above average in profitability compared to the other industries. In 1983 most aluminum operations experienced some improvement, but this did not persist. Profits, which had peaked briefly at $0.37 per pound in 1980, became a $0.30 loss in 1982, returning to a $0.05 profit in 1983, but then slipping to a $0.19 loss in 1984. The price and profit situation remained unfavorable on into 1985. 2/ (See table VII:2).

C. Competitive Factors

In the 25 years from World War II to 1970 aluminum consistently outperformed expectations as consumption followed a steep exponential climb. This fast rate of growth could only be sustained for so long and aluminum has begun to behave like a mature industry. While this eventuality may appear obvious, the firms and countries involved did not seem prepared for it to happen and continued to expand capacity.

1/ Includes centrally planned and market economy countries. U.S. Department of the Interior. Bureau of Mines. Aluminum. Preprint from Bulletin 675. 1985. p. 1.

2/ Aluminum Supplement. American Metal Market. January 13, 1984.

Table VII:2: Trends in U.S. Aluminum Industry Performance 1960, 1970, 1980, and 1983

	1960	1970	1980	1983
Bauxite production (1,000 MT)	2,030	2,115	1,559	679
Alumina production (1,000 MT)	3,652	6,555	6,810	4,000
Alumina capacity (1,000 MT)	--	--	7,208	7,145
Capacity utilization (percent)	--	--	94	56
Aluminum production (1,000 ST)	2,014	3,976	5,130	3,696
Aluminum capacity (1,000 ST)	2,469	4,263	5,503	5,513
Capacity utilization (percent)	82	93	93	67
U.S. producer list price (¢ per lb.)	26.0	28.7	71.6	77.8
U.S. spot price (¢ per lb.)	--	28.7	79.0	68.3
Bauxite mine employment	750	350	314	110
Primary aluminum employment	17,000	21,000	23,000	21,000

MT = Metric tons.
ST = Short tons.
-- = Not available.

Source: U.S. Bureau of Mines. Minerals Yearbook and Mineral Commodity Summaries. [various issues].

Some markets became saturated in the short-term, new materials begin to appear to compete against aluminum, the accumulation of primary metal in the hands of consumers began to flow back faster as scrap, and eventually there was a slowing of the underlying growth rate of the world's industrial economy as a whole. In the United States, new building and construction languished in some years, and the energy-intensive, "buy-a-new-model-every-year", throw-away American society began to change from its previous consumption patterns. Table VII:3 demonstrates how dramatically and rather quickly the outlook for aluminum changed.

Table VII:3. U.S. Consumption Trends 1960, 1970, 1980, and 1983

Year	Apparent Consumption	Percentage Increase
1960	2,015	--
1970	4,519	+124
1980	5,065	+ 12
1983	5,543	+ 9

Source: U.S. Bureau of Mines. Minerals Yearbook. [various years].

In this same period, the supply side of the picture also went through dramatic changes. The integrated, primary metal producers of the United States, Canada, Japan, and Europe moved to assure themselves of future supplies of alumina and power. Exploration revealed new sources of bauxite, such as major discoveries in Australia and Brazil. The bauxite producers themselves became more nationalistic and aggressive in seeking to gain greater control over their production. They also began to produce higher value-added production of alumina. Investments in new facilities became so much more geographically diverse, however, that it became obvious that this new nationalism could not develop into a new "OPEC" in bauxite. Open markets replaced the mostly intra-company transfers that characterized the aluminum industry when it was controlled by the six majors. As demand slowed and capacity expanded beyond immediate needs those metal producers with access to reliable low-cost energy were able to survive best when the open market price fell 45 percent in the Rotterdam market and 30 percent on the London Metal Exchange in 1985. After twenty years of expansion in metal production, Japan decided to retrench its industry and production which exceeded a million tons in the 1970s fell to 287,000 metric tons of metal by 1984.

By 1980, the international aluminum industry was no longer a closely knit group centered in a few countries and comprised of a few companies. An ability to keep capacity expansion closely adjusted to market requirements no longer seemed to exist. The newer government-controlled operations were reluctant to restrain operations in periods of market surplus or to close uneconomic facilities. Once primary metal supplies exceeded immediate market demand, metal consumers found it useful to reduce their growing inventory costs due to high interest rates by assuming that producers could deliver metal upon demand. As a result, whenever aluminum smelters misjudged actual demand, prices reacted with much more volatility than had been traditional in the industry. The situation is aggravated by the fact that alumina is hard to store and metal potlines need to be operated

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on a continuous basis. Currently, the presence of idle capacity and the size of producer and consumer inventories does not suggest that there will be any shortage of immediately available or deliverable metal for some time to come.

The United States emerged from all of these developments as one of the higher cost primary aluminum producers in the world. In the past, the range between the highest and lowest cost smelters in the world was a few cents a pound. Today, however, significant power cost differentials exist between smelters, causing operating costs to vary substantially. This is not only a reflection of the rapid increase in the world and domestic price of energy in general but changes in the electric power industry. With the growth in demand for electricity in regions where power had once been abundant and cheap, the rate structures were modified. Hydroelectric power from Bonneville Power Authority in the Pacific Northwest for aluminum production went from 6 mills/kWh to 26 mills/kWh in two years.

In 1984, operating costs of the majority of western world aluminum smelters have been estimated to be between $0.40 and $0.70 per pound, with an average of $0.52 per pound. 3/ U.S. aluminum smelter operating costs in the Pacific Northwest (which accounts for roughly one-third of total U.S. aluminum capacity) have been estimated to be between $0.55 and $0.74 per pound, with an average of $0.64 per pound. 4/ Cost factors other than power also tend to exacerbate the U.S. movement toward the higher end of the cost range. These other cost factors include raw materials, labor, capital, and environmental, and governmental regulations such as health and safety requirements. U.S. operating costs are now forecast to remain at these higher levels in the face of constant or even declining prices for primary aluminum.

Since about one-fourth of the cost of producing aluminum is attributable to electricity costs, energy is the critical element in the case of aluminum compared to the other metals industries. Although the electricity bought by U.S. aluminum producers costs less per unit than the national average, the increases in those power costs have been the major upward pressure on production costs. The rates charged by the various utilities serving the aluminum industry reflect their own increases in cost, including construction cost

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3/ Average cost before allowing for capital charges such as interest and depreciation. Estimates from a report by Anthony Bird Associates. Cited in Mining Journal (London). Production Costs Set to Rise. December 21, 1984. p. 428.

4/ U.S. Department of Commerce. International Trade Administration. Energy and the Primary Aluminum Industry. Report by James S. Kennedy. Washington. U.S. Gov. Print. Off. January 1985. p. viii.

overruns, in order to provide new generating capacity to service emerging consumers other than the aluminum industry, such as agriculture and residential users. As a result, long-term power contracts at favorable rates are harder to negotiate and price increases are more frequent than in the past.

The U.S. Department of Commerce estimates that the weighted average cost of power to U.S. aluminum producers was 23 mills/kWh in 1983 compared to 17 mills/kWh for the market economy countries, exclusive of the U.S. If certain high cost Asian producers (such as Japan) are also excluded, the average drops to 12 mills/kWh. This comparison persists despite technological advances in aluminum production that have enabled U.S. producers to reduce costs through energy conservation. Electricity use in aluminum production has been reduced 50 percent since 1940.

The electric power situation in a number of competitor countries is strikingly different from the United States. In Canada, Alcan produces its own power and has an abundant capacity to meet its needs. The utility companies in the province of Quebec, unlike the pattern that has appeared in the United States, intentionally keep rate structures favorable for local industry. In France, where the nuclear power program created excess capacity, power has been made available on favorable terms. Both Brazil and Australia, as they emerge as major, new aluminum sources, have priced power to assist their export industries. Norway, with its large hydropower resource potential, has a natural advantage in its cost of electricity.

While power is the "swing" cost factor, raw materials are the largest cost component for aluminum smelters. In addition to its reliance on foreign sources of bauxite, and increasingly alumina, the U.S industry since the 1970s has had to contend with escalating shipping costs, shipping strikes, increases in foreign export taxes, raised levies on bauxite extraction, requirements that North American primary producers make additional investments in foreign operations, and the effects of political instability within certain source countries. 5/

These other cost factors have had varying incremental impacts on the U.S. aluminum operating cost picture. In 1983, aluminum workers, whose average hourly wage was $16.36, became the highest paid industrial workers in the United States, exceeding those in automobiles and steel. 6/ Also, rising interest rates after 1978 increased the capital cost of aluminum production facilities in excess of the

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5/ Drewry Shipping Consultants Ltd. The Outlook for Bauxite/Alumina Trade and Shipping. Study #124. July 1984.

6/ U.S. Department of Commerce. Industrial Outlook 1984.

national inflation rate. Costly electrostatic precipitators to control alumina refinery stack discharges, plus mine and plant safety requirements, have added to production costs. Nonetheless, capital costs tend to be lower in the United States than in many other nations, especially Third World countries, because there is less need for infrastructure expenditures.

D. Market Trends

As noted previously, aluminum prices declined worldwide as demand decreased and inventories expanded. The introduction of commodity exchange-based pricing of aluminum in 1978 reduced the influence of producer list prices which had tended to be stable. Today, changes in the world supply and demand balance for aluminum are an important pricing variable, leading to increased aluminum price volatility. Most of the newly emerged aluminum producers around the world have only small local markets for their aluminum, and therefore must sell it on the open "exchange" market. This has increased the availability of merchant material, much of it at a very low cost. This significant increase in tonnage on the market has contributed to the depressed prices that have prevailed for most of the 1980s.

Governmental, or quasi-governmental ownership of market economy primary aluminum production capacity has substantially increased, from less than 10 percent in 1960 to 35 percent in 1983. Eleven of the leading twenty-five owners of primary aluminum capacity are governments. In addition, countries such as Jamaica, Venezuela, Brazil, Guinea, and Australia have taken measures to assert increased national control over bauxite mining projects within their borders, either by requiring additional investments by foreign firms or by nationalization of companies. These foreign governments have used a variety of means to maintain their aluminum industries and/or to attract new smelters, including offering financial assistance, reduced electricity rates, and electricity rate stabilization. In many instances, these governments own or control the electric power industry, as well as the aluminum industry, and can establish operating and cost objectives consistent with their national concerns.

Some specific examples of this increased foreign government intervention in world bauxite/aluminum production follow. Italy has assumed losses incurred by its state company MCS, while France in 1983 nationalized its aluminum industry. West Germany's regional government of Baden-Wurttemberg has established low electricity rates to help a smelter there, and both federal and regional governments are subsidizing a smelter at Ludwigshaven. Brazilian production is shifting location within the country as a result of decisions made to develop the Amazon region, giving priority to the aluminum industry in this strategy.

U.S. imports of aluminum have surged during the 1980s, due in large part to the strength of the dollar. Despite depressed price conditions, many foreign producers find it more profitable to sell aluminum in the U.S. for dollars rather than in their home markets. The source countries for imports have undergone changes since the 1960s. Table VII:4 shows the imports of bauxite, alumina, and aluminum during 1960-83 by quantity, and top three import sources.

Table VII:4. U.S. Imports of Bauxite, Alumina, and Aluminum

Bauxite

Year	Quantity (1,000 MT)	Top Three Sources
1960	8,884	Jamaica, Suriname, Dominican Republic
1970	12,822	Jamaica, Suriname, Dominican Republic
1980	14,087	Jamaica, Guinea, Suriname
1983	7,601	Guinea, Jamaica, Brazil

MT = Metric tons.

Alumina

Year	Quantity (1,000 MT)	Top Three Sources
1960	80	Japan, West Germany a/
1970	2,317	Australia, Jamaica, Suriname
1980	4,358	Australia, Jamaica, Suriname
1983	4,030	Australia, Jamaica, Suriname

MT = Metric tons.
a/ No others.

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Table VII:4. U.S. Imports of Bauxite, Alumina, and Aluminum (continued)

Aluminum

Year	Quantity (short tons)	Top Three Sources
1960	154,706	Canada, Norway, France
1970	350,060	Canada, Norway, Poland
1980	580,515	Canada, Ghana, West Germany
1983	818,676	Canada, Venezuela, Ghana

Source: U.S. Bureau of Mines. Minerals Yearbook. [various years].

As imports grew, U.S. aluminum export markets weakened. European producers, like their U.S. counterparts, have suffered from above-normal inventories and continued efforts to cope with slow internal growth. Likewise, the strong U.S. dollar has made purchases of American aluminum by foreign firms a less attractive alternative to other sources of supply. Table VII:5 shows the exports of bauxite, alumina, and aluminum separately during 1960-83 by quantity, and top three export markets.

The recycling of used or scrap aluminum has become economically important to the entire aluminum industry and is highly developed in the United States, accounting for approximately a quarter of aluminum supply. U.S. secondary reliance is comparable to that worldwide, although scrap accounts for a considerably larger share in certain countries (e.g., about one-half of the total aluminum supply in Japan). The supply of aluminum scrap has grown as more aluminum products become available for recycling. Programs for the collecting and recycling of used beverage cans (about one-half of the cans produced are recycled) account in large part for the increase in scrap supply. This has been accompanied by an increase in the secondary industry's contribution to total domestic aluminum supply.

Using recycled aluminum enables fabricators to avoid the large capital outlays and production problems experienced when obtaining and processing bauxite into aluminum and reduced operating and transportation costs. Recycling aluminum requires only 10 percent of the

Table VII:5. U.S. Exports of Bauxite, Alumina, and Aluminum

Bauxite

Year	Quantity (1,000 MT)	Top Three Markets
1960	30	Canada, Mexico, Europe
1970	3	Canada, West Germany
1980	28	Canada, Mexico
1983	74	Mexico, Canada

MT = Metric tons.

Alumina

Year	Quantity (1,000 MT)	Top Three Sources
1960	32	Norway
1970	1,110	Canada, U.S.S.R., Norway
1980	1,138	Canada, Norway, Venezuela
1983	591	Norway, Mexico, Sweden

MT = Metric tons.

Aluminum

Year	Quantity (short tons)	Top Three Markets
1960	284,979	United Kingdom, West Germany, France
1970	408,452	France, Japan, West Germany
1980	714,906	Japan, Korea, Mexico
1983	397,608	Japan, China, Taiwan

Source: U.S. Bureau of Mines. Minerals Yearbook. [various years].

capital investment needed to produce aluminum from bauxite and alumina and only 5 percent of the energy. This offers the attraction of reducing U.S. dependence on foreign bauxite/alumina supplies with its accompanying political risks and capital outflows. In addition, there has been a tremendous increase in export market demand by foreign industries for secondary aluminum. Table VII:6 shows the recovery and exportation of secondary aluminum during 1960-83 by quantity and top three export markets.

Table VII:6. Secondary Aluminum - Supply and Exports

Year	Secondary Recovery (short tons)	Scrap exports (short tons)	Top Three Markets
1960	329,000	79,513	West Germany, Italy, Japan
1970	781,000	57,159	West Germany, Italy, Canada
1980	1,389,000	444,681	Japan, West Germany, Mexico
1983	1,724,000	262,159	Japan, Canada, Mexico

Source: U.S. Bureau of Mines. Minerals Yearbook. [various years].

E. U.S. Industry's Response to Current Conditions

The sharp rise in world energy prices during the 1970s, the shift in the product and service mix comprising gross domestic product (GDP), new technology, lower birth rates, and aging populations in most industrialized countries, slower GDP growth rates, financial and debt servicing problems in the Third World, and shifts in consumer preferences have also contributed to the considerably altered underlying economics of aluminum production. The past comparative advantage of the United States, Japan, and a number of European countries that have traditionally been major aluminum producers has waned, while in certain other countries, particularly Australia and Brazil, it has increased. The U.S. aluminum industry is now in the midst of a major transition in response to all of these charges. Both the large integrated aluminum firms and the smaller independent aluminum companies have been divesting their unprofitable sectors and strengthening the management and operations of their successful sectors. The latest price slump, has caused the restructuring of the U.S. aluminum industry to proceed much quicker than first expected.

Since 1980, the aluminum industry has taken six major steps in response to competitive trends in restructuring the industry. First, a number of the highest cost smelters have been permanently closed. Since 1980, production capacity of the primary aluminum industry has been reduced about 14 percent. 7/

Second, U.S. producers increasingly tend to act as "swing suppliers", cutting back primary production in times of weak demand and low aluminum prices. In contrast, ore-rich mining nations, such as Australia, Guinea, Jamaica, and Brazil are "base suppliers". After reaching record high levels of production in 1980, 810,650 tons of production in 1981 and 964,550 tons of production in 1982 were shut down due to the decline in general economic conditions and a weak aluminum market. By late 1982, the operating rate of primary smelters was at an all-time low of 58 percent of capacity. U.S. primary aluminum capacity utilization increased to 67 percent, in 1983, but five smelters remained temporarily shut down and seven operated at reduced rates.

Third, the leading U.S. producers are, despite disinterest in primary capacity, investing heavily in upgrading their fabricating plants to keep them competitive. Investments of more than $300 million have reportedly been made by the major companies in recent years to upgrade the quality and capacity of their domestic rolling facilities. This suggests they plan to specialize in these kinds of products in the future.

Fourth, the major integrated U.S. aluminum producers are withdrawing from any semi-fabricated product lines in which they have suffered a competitive disadvantage, such as extrusions, rod, bar, and wire businesses, and can manufacturing. During 1983, extrusion plants were closed in Halethorpe, Maryland; Dalton, Illinois; and Phoenix, Arizona. Similarly, a can manufacturing plant in Woodbridge, New Jersey and a wire, rod, and bar facility in Listerhill, Alabama were closed. Plants sold or up for sale included an extrusion plant in Woodbury, New York, and can manufacturing plants in Houston, Texas; Jacksonville, Florida; Wanatah, Indiana; Edison, New Jersey; and Union City, California.

Fifth, U.S. aluminum producers are making extensive efforts to bolster their cash flows and cut their costs. Some of their strategies have included paring inventories, reducing staffing levels, selling common equity, and selling their physical assets. In addition, many of them are working hard to build up recycling systems so that they can reduce the average costs of their metal. In an effort to reduce labor costs, the major aluminum producers and the United

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7/ American Mining Congress Journal. Aluminum producers curtail production. January 15, 1986. p. 11.

Steelworkers and Aluminum, Brick, and Glass Workers unions signed a three year master labor contract in 1983 which included a freeze on wages, modified cost-of-living-adjustment provisions, and some cuts in benefits and bonuses. New, lower electricity rates have been negotiated by a number of smelters to lower their production costs.

Sixth, the major domestic aluminum companies are adopting new market strategies that reflect a trend toward disintegration. The leading producers are concentrating on developing new uses for aluminum in the hope of creating growth. Some U.S. aluminum producers, such as Alcoa are planning to diversify into other businesses, preferring to be recognized as materials companies, and not strictly as aluminum companies. Other U.S. producers are getting out of the business. In 1984, two of the intermediate-sized U.S. producers, Atlantic Richfield and Martin Marietta, decided to get out of the aluminum business completely.

F. Outlook

Despite these changes and market softness, one should not class the U.S. aluminum sector in its totality as being in jeopardy. The U.S. wrought aluminum industry is still highly competitive. The multinational U.S. aluminum firms are responding to the global restructuring of the industry. They are facing up to the high energy costs and other variables that cause high production costs as well as to other operating and economic factors that have undermined their international competitiveness in the face of low-cost hydropower, low labor costs, governmental involvement, and other factors that aid foreign firms. There is, of course, concern and apprehension among the U.S. producers of semi-fabricated aluminum products about this restructuring.

It is now forecast by the U.S. aluminum industry that most future imports into the United States will be alumina, or aluminum, not bauxite. The U.S. primary aluminum producers, as international companies, are shifting to increased reliance on smelters abroad to supply their U.S. fabricating operations with low-cost ingot. They are investing heavily in new, low-cost smelters outside of the U.S. The differential in world power costs has been the most important determinant in selecting sites for these new primary aluminum smelters, and, during recessions, the most important factor in determining which smelters continue to operate.

It has also been forecast by the aluminum industry that future growth in the U.S. industry will take place mainly downstream, in fabricating intermediate and end-products. For some time now, foreign producers, which already have low-cost smelters in their own countries, have been buying aluminum fabricating plants in the United States to gain a foothold in the U.S. market for downstream products.

The consensus now being voiced by the U.S. aluminum industry is that given the competitive realities it is unlikely that the U.S. will ever again produce as much primary aluminum as it did in 1980. Even newly emerging technologies, such as the "bipolar" cell with its promise of improving smelter efficiency, are unlikely to change that overlook given the *status quo*. 8/ All U.S. aluminum producers have recognized that the strong dollar has affected their competitiveness vis-a-vis imports. But they do not seem to expect that the weaker dollar now appearing will change the fundamentals. The integrated, multinational aluminum firms operating in the U.S. seem to believe that with restructuring they will benefit from their leadership in light metals technology and that their fabricating operations will remain internationally competitive. 9/ The Aluminum Association, whose membership includes producers of foil, sheet and plate, appears less sanguine and has called for across-the-board federal action on all elements of cost and trading disadvantages to protect them against foreign products entering the United States. 10/ There are also those who would suggest that the United States should more aggressively pursue research that would eventually permit the use of indigenous non-bauxite sources of aluminum and a return to some level of domestic independence from foreign supplies. The means to accomplish this and the time it would take are not readily determinable.

8/ Strategic Materials Management. December 1, 1984. p. 3.

9/ U.S. Department of Commerce. International Trade Administration. Energy and the Primary Aluminum Industry. January 1985. p. xi.

10/ Strategic Materials Management. December 15, 1985. p. 3.

VIII. FERROALLOYS*

A. Introduction

The United States possesses no economic reserves of two major alloying ores--chrome and manganese--and thus must import them in some form for use in the production of iron and steel. Manganese is important not only for the properties it provides the finished steel but also as an ingredient in the steel-making process itself. Chromium imparts such vital properties as heat and corrosion resistance to a variety of specialty steels.

As recently as 1977, domestic integrated steel producers imported the various alloying elements in a raw form, and then processed them for final use in the manufacture of finished steel shapes. In the past decade, U.S. capacity for processing ferroalloys has declined and has grown in nations with sizable reserves of the needed ores. This trend exhibits many of the factors noted in the discussion of the nonferrous mining and processing industries, as well as in the processing and refining of bauxite and alumina into aluminum. Obviously, the ferroalloys industry has also felt the impact, as has iron ore mining, of the declining performance of the domestic iron and steel industry itself.

This chapter examines the particular combination of factors, such changes in technology, the appearance of overseas production capacity, the strength of the dollar, and growth in the cost of electricity, that have forced the U.S. ferroalloy industry to restructure.

B. Industry Structure†

Ferroalloys: Definition and Use

The American Society for Metals and the U.S. Bureau of Mines define a ferroalloy as "an alloy of iron that contains a sufficient amount of one or more chemical elements to be useful as an agent for introducing these elements into molten metal, usually steel." 1/ Of the 12 ferroalloys consumed in the United States, ferrochromium, ferromanganese, and ferrosilicon are the principal ones: in 1983, the three combined represented 79 percent of domestic consumption. 2/

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*Prepared by Gary L. Guenther, Analyst in Industry Economics, Economics Division.

†Most of this assessment of the structure of the U.S. ferroalloys industry has been adapted from an earlier CRS report. See: U.S. Library of Congress. Congressional Research Service. The Ferroalloy Industry: Current Conditions and Policy Options. Typed Report, by David J. Cantor, Bernard A. Gelb, Gary L. Guenther, and Dick K. Nanto, May 10, 1983. Washington, 1983.

Ferroalloys impart vital properties to and play key roles in the production of steel and iron castings. Depending on the alloy, they enhance the hardness, strength, malleability, and corrosion resistance of ferrous metals; at the same time, depending again on the metal, they cleanse, deoxydize, and innoculate these metals as they are formed. The steel and iron foundry industries account for nearly all domestic ferroalloys consumption: in 1983, the two industries' share of consumption came to 90 percent. 3/

Ferroalloys play an important role in the economy, a role disproportionate to their direct contribution to overall economic activity. Their importance stems from their use in iron and steel production. Under current steelmaking and casting technologies, no carbon, stainless, alloy, or heat-resisting steel or iron castings could be produced in the United States if ferroalloys could not be produced domestically or imported. The loss to the economy would probably far exceed the .006 percent of Gross National Product (GNP) and .005 percent of nonagricultural employment the ferroalloys industry accounted for in 1982.

Industry Structure, Processes, and Costs

The ferroalloys industry comprises plants primarily engaged in the production of ferrous and nonferrous alloying elements through electrometallurgical or metallothermic processes. None of the domestic plants in operation today is owned by a steel company. 4/ Despite rising competition from imports, the U.S. industry as a whole has expanded over the past decade or so. According to the Bureau of Mines, 37 companies produced ferroalloys at 56 locations in 1983, compared with 29 companies at 50 locations in 1970. Most of this expansion has been concentrated in the smallest product lines, which tend to be highly specialized.

1/ U.S. Department of the Interior, Bureau of Mines. Mineral Facts and Problems. Bulletin 671. Washington, 1980. p. 294.

2/ Bureau of Mines. Preprint from the 1983 Minerals Yearbook: Ferroalloys. Washington, 1983. p. 5-6.

3/ Ibid., p. 5-6.

4/ Ferroalloys: Competition Is Still Fierce. Chemical Week, September 5, 1984. p. 30.

The industry can be divided into three segments: (1) producers of bulk or "tonnage" ferroalloys--chromium, manganese, and silicon ferroalloys and their respective metals; (2) producers of specialty ferroalloys--titanium, boron, molybdenum, tungsten, vanadium, columbium, and nickel ferroalloys; and (3) producers of ferrophosphorus. There is reason to believe, however, that all the expansion between 1970 and 1983 took place in the latter two segments, whose combined output is typically about one-fifth that of the three bulk ferroalloys. The Ferroalloys Association reports that the number of domestic plants producing ferrochromium, ferromanganese, or ferrosilicon dropped from 29 on January 1, 1978 to 17 on January 1, 1985.

Ferroalloys production involves the smelting of various ores. Electric furnaces accounted for about 98 percent of domestic ferroalloys production in 1983. 5/ These furnaces are specially suited to the production of chromium, manganese, and silicon ferroalloys and metals. The electric arc generates the high temperatures and energy needed to produce high carbon ferromanganese, ferrosilicon, and high carbon ferrochromium. In many countries blast furnaces are used to produce ferromanganese. In the United States, however, no ferromanganese has been produced in a blast furnace since 1977, when the Bethlehem Steel Corporation closed its mill in Johnstown, Pennsylvania. 6/

As in all smelting, raw materials and energy contribute the most to the variable cost of producing a ton of ferroalloys. According to the Census Bureau, variable costs for the domestic ferroalloys industry totalled $1.025 billion in 1981; of this, labor accounted for 16.4 percent, purchased energy for 24.2 percent, and materials for 59.4 percent. 7/ These figures, however, should be regarded as an average for the industry, since the distribution of variable cost differs by type of ferroalloy and by producer. For example, energy costs can range from 20 to 50 percent of the total.

5/ Bureau of Mines. Preprint from the 1983 Minerals Yearbook. Feroalloys. Washington, 1983. p. 22.

6/ U.S. Department of Commerce. Critical Material Requirements of the U.S. Steel Industry. Washington, March 1983. p. 94.

7/ The same figures in 1977 were 16.8 percent for labor, 62.4 percent for materials, and 20.8 percent for purchased energy. Most of the increase in energy's share between 1977 and 1981 can be attributed to rises in the cost of electricity. According to data published by the Energy Information Administration, the average price of electricity sold by privately owned utilities to industrial users rose by nearly 72 percent in that period.

Ferroalloys production is highly energy-intensive. In 1981, purchased energy used per dollar of value-added in ferroally production was 10.5 times the average for all manufacturing, and 2.5 times that for basic steel production. 8/ Reflecting the dominant process technology in the industry, electricity is by far the biggest source of energy in ferroalloys production. In 1981, electricity accounted for 79 percent of the cost of energy purchased by U.S. ferroalloys producers. 9/ It should be noted, however, that producers differ widely in cost structure.

C. Ferroalloys and the U.S. Steel and Iron Castings Markets

The demand for ferroalloys is derived primarily from the demand for all grades of steel and iron castings. The most recent recession illuminates this link. When the domestic steel and foundry industries slid into recession during 1981-82 and early 1983, domestic ferroalloys consumption slackened considerably. Between 1981 and 1983, the two industries accounted for an average of 90 percent of consumption. Table VIII:1 gives figures on steel and iron castings production and ferroalloys consumption in recent years.

The use of ferroalloys in steelmaking depends not only on the level of raw steel production but also on its composition. 'Composition' here refers to the distribution of total output among the three main grades of steel: carbon, stainless--including heat-resisting steels, and alloy--including tool steels.

The importance of the composition of output becomes clear when one examines the year-to-year changes in the mix of raw steel output. In 1970, 89.3 percent of domestic raw steel output went into the manufacture of carbon steel shapes; 9.7 percent into alloy steel shapes; and 1.0 percent into stainless steel shapes. By contrast, the same shares in 1983 were carbon steel--87.2 percent, alloy steel--10.7 percent, and stainless steel--2.1 percent. (See table VIII:2 for the distribution in other years.) Under existing steelmaking technologies, alloy and stainless steel use more ferroalloys per unit than carbon steel. In 1983, for example, each ton of raw carbon steel produced contained an average of 12.7 pounds of ferroalloys, compared with 43.2 pounds for raw alloy steel and 310.2 pounds for raw stainless steel. 10/

8/ U.S. Department of Commerce, Bureau of the Census. 1982 Census of Manufactures: Fuels and Electric Energy Consumed. Part 1. Industry Groups and Industries. Washington, June 1983. p. 4-8 and 4-18.

9/ Ibid., p. 4-18.

10/ Based on data published by the American Iron and Steel Institute and the Bureau of Mines.

Table VIII:1. U.S. Raw Steel and Iron Castings Production and Ferroalloys Use in Selected Recent Years (thousands of short tons)

Year	U.S. Raw Steel Production	U.S. Iron Castings Shipments	Ferroalloys Used by Steelmakers and Iron Foundaries	Percent of U.S. Ferroalloys Use
1970	133,241	14,798	1,942	91.5
1975	116,642	13,177	1,877	92.8
1978	137,031	16,116	2,218	92.1
1979	136,341	15,317	2,190	92.0
1980	111,835	12,249	1,742	89.8
1981	120,828	12,351	1,784	90.8
1982	74,577	8,512	1,066	90.2
1983	84,615	9,538	1,140	89.5

Sources: Compiled by CRS from data supplied by the American Iron and Steel Institute and the U.S. Department of the Interior, Bureau of Mines.

Table VIII:2. Distribution of U.S. Raw Steel Production by Grade in Recent Years (thousands of short tons).

	Carbon		Stainless		Alloy	
Year	Tonnage	% of Total	Tonnage	% of Total	Tonnage	% of Total
1970	117,411	89.3	1,279	1.0	12,824	9.7
1975	100,360	86.0	1,111	1.0	15,171	13.0
1978	116,916	85.3	1,954	1.4	18,161	13.3
1979	116,226	85.3	2,107	1.5	18,008	13.3
1980	94,689	84.7	1,701	1.5	15,445	13.8
1981	101,462	84.0	1,743	1.4	17,623	14.6
1982	64,143	86.0	1,235	1.7	9,198	12.3
1983	73,783	87.2	1,750	2.1	9,082	10.7

Source: Compiled by CRS from data supplied by the American Iron and Steel Institute.

Stainless steel illustrates the complexity of ferroalloy needs. It can be made from a myriad of alloys in varying combinations. The range of possibilities can be reduced to two basic categories: steel containing a minimum of 10 percent chromium (with and without other alloys) and steel containing a minimum of 18 percent chromium (with and without other alloys). Alloying elements can account for up to one-half the weight of stainless steel. Besides chromium, the major ones are cobalt, columbium, nickel, tantalum, molybdenum, tungsten, vanadium, titanium, and silicon. 11/

Improvements in steel process technologies offer an opportunity to lower alloy requirements. Continuous casting is increasingly being used as a method of converting molten steel into semi-finished shapes. One of the main benefits of switching to continuous casting is an increase in yield, or the average amount of finished steel that can be produced from a ton of raw steel. This has important implications for the use of ferroalloys in steelmaking. As more and more steelmakers adopt this technology, the average amount of ferroalloys used per ton of finished steel shipped should gradually fall, all other things being equal. Continuous casting has been responsible for a major part of the 25 percent drop between 1975 and 1983 in the average amount of ferroalloys used per ton of finished steel shipped by U.S. producers. But there is evidence that continuous casting may now be reaching its technical optimum in stainless steelmaking.

Other process innovations have fundamentally altered the mix of alloys used in certain steelmaking processes. One in particular is a method of producing stainless steel known as argon oxygen decarburization (AOD). It reduces the loss of chromium in the removal of carbon during melting. As a result, materials with a lower chromium and a higher carbon content can be used to make stainless steel. In practice, stainless steel producers with AOD furnaces have been substituting cheaper high-carbon ferrochromium for low-carbon ferrochromium. 12/

The U.S. specialty steel industry has invested heavily in AOD furnaces since the late 1960s. By 1978, the United States held 41 percent of installed AOD capacity worldwide. 13/ Today, nearly all U.S. stainless steel capacity is in the form of AOD furnaces. The diffusion of the AOD technology has led to a surge in the use of high-carbon ferrochromium in domestic stainless steel production: the amount of high-carbon ferrochromium used per ton of raw stainless steel produced was 3.2 times greater in 1983 than in 1969.

The price of substitutes can also influence the demand for specific ferroalloys by steelmakers. Under existing steelmaking technologies and current prices for ferroalloys and their known

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11/ Ibid., p. 22.

12/ Commerce Department. Critical Material Requirements of the U.S. Steel Industry. p. 26.

13/ U.S. Congress. Office of Technology Assessment. Technology and Steel Industry Competitiveness. Washington. U.S. Govt. Print. Office, 1980. p. 282.

substitutes, the only practical substitute for certain ferroalloys is scrap. This is mainly true of three ferroalloys used to produce stainless and alloy steels: nickel, molybdenum, and chromium. 14/

A recent report by the International Trade Commission (ITC) sheds some light on the potential impact of changing scrap prices on the demand for certain ferroalloys. In a 1981 investigation of the U.S. market for high-carbon ferrochromium, the ITC found that the price of stainless scrap is a key factor in domestic consumption of the ferroalloy. Using detailed data on domestic consumption of high-carbon ferrochromium between the first quarter in 1974 and the second quarter in 1978, the ITC estimated that a 1.0 percent rise in the price of the ferroalloy could lead to a decline in consumption of 0.88 percent; most of this decline would be offset by an increase in scrap usage. 15/

For much of the period since 1980, the U.S. steel industry has been beleaguered by prolonged recession and rising foreign competition in key domestic markets. The combined effect of the two developments has been to depress domestic steel output--directly--and ferroalloys consumption--indirectly. Since 1979, shipments of steel mill products by domestic producers have not exceeded 100 million tons--they reached a post-World War II low of 61.6 million tons in 1982--industry employment has fallen without interruption; and import penetration has climbed in each year except 1983, reaching an estimated all-time high of 26.7 percent of apparent domestic consumption in 1984. 16/ The key elements in the short-term outlook for the use of ferroalloys by domestic steelmakers are (1) the level of steel demand, (2) the composition of domestic steel output, and (3) the level of import competition, especially in markets for alloy and stainless steels.

Iron Castings Market

The other major U.S. market for ferroalloys is iron castings. In 1983, iron foundries accounted for around 16 percent of domestic consumption. The principal ferroalloy in iron castings production is ferrosilicon: in 1983, 85 percent of the volume of ferroalloys used by iron foundries was in the form of ferrosilicon. As in the case of steel, the level and mix of iron castings production are key

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14/ Based on a telephone conversation with George Watson of the Ferroalloys Association on March 12, 1985.

15/ Internatinoal Trade Commission. High-Carbon Ferrochromium. USITC Publication 1185. Washington, September 1981. p. A-68.

16/ Date Resources, Inc. DRI Steel Industry Review: First Quarter 1985. Lexington, MA, 1985. p. 8.

determinants of ferroalloys use by foundries. The main types of iron castings are grey, ductile, and malleable. Ductile castings require the largest volume of ferroalloys, followed by grey iron and malleable.

There is some evidence that the foundry industry has been losing importance as a market for ferroalloys in recent years. Between 1975 and 1983, the amount of ferroalloys used per ton of iron castings shipped in the United States decreased by 30 percent. Improvements in process technologies, which have reduced the need for ferrosilicon in iron castings production, are thought to be responsible for part of this decline. 17/

Like the steel industry, U.S. iron foundries have been faced with slumping markets and import competition in recent years. Since 1979, shipments of iron castings by domestic producers have not exceeded 15 million tons; industry employment has steadily dropped; the industry has recorded more unprofitable years--1980, 1982, and 1983--than profitable ones; and imports have captured increasing shares of the domestic market, reaching an estimated all-time high of nearly 17 percent of shipments by U.S. producers in 1984. 18/

Iron foundries are expected to continue their recovery from the 1981-82 recession. DRI projects that shipments of iron castings will grow at an average annual rate of 3.9 percent between 1984 and 1987, compared to an average annual rate of -8.0 percent between 1980 and 1983. 19/ Whether domestic foundries will be the primary beneficiary of this projected growth remains to be seen, for the U.S. foundry industry currently enjoys no special protection from imports.

D. Structural Change in the U.S. Ferroalloys Industry: The Recent Performance of U.S. Producers of Ferrochromium, Ferromanganese and Ferrosilicon

Over the past decade, the structure of the domestic ferroalloys industry has changed markedly. Most of the changes have been concentrated in the largest segment of the industry: producers of

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17/ Based on a telephone conversation with Roy Lobenhofer, a technical specialist with the American Foundryman's Association, on March 20, 1985.

18/ U.S. Department of Commerce. International Trade Administration. 1985 U.S. Industrial Outlook. Washington, January 1985. p. 19-6.

19/ Data Resources, Inc. Steel Industry Review. p. 15.

the tonnage ferroalloys--ferrochromium, ferromanganese, and ferrosilicon. The key changes have been rises in the share of the U.S. market held by foreign producers and declines in domestic production capacity. 20/

The recent condition of tonnage producers epitomizes their plight. In 1983, according to data compiled by the Ferroalloys Association, imports of chromium, manganese, and silicon ferroalloys and metals accounted for 58 percent of apparent domestic consumption. What is more, in the same year, U.S. producers of the three ferroalloys operated at an average rate of 35 percent of capacity, employed an average of 3800 workers--compared to 8500 in 1979--and lost $65 million.

Ferrochromium

The U.S. ferrochromium market has seen a steady rise in import competition since 1970. This rise is shown in table VIII:3. Imports accounted for 13 percent of apparent domestic ferrochromium consumption in 1970; in 1983, their share was 87 percent, the highest level ever.

Reflecting the shift in domestic consumption patterns, most of the growth in the volume of imports has been concentrated in the market for high-carbon ferrochromium. In 1981, when U.S. ferrochromium imports reached their highest level to date, imports of high-carbon ferrochromium totalled about 220,000 short tons (chromium content) and imports of low-carbon ferrochromium, around 27,000 short tons. By contrast, in 1970, imports of the former came to less than 50 percent of the latter.

U.S. ferrochromium producers have responded to the growth in import competition by closing uneconomic capacity and by shifting their productive resources out of ferrochromium production and into the production of specialty chromium alloys and metals. According to the Ferroalloys Association, domestic ferrochromium capacity has fallen by 50 percent over the past 12 years: it was about 400,000 short tons on January 1, 1973; but it had dropped to around 200,000 short tons two years later. Although five U.S. companies currently produce some type of chromium alloy or metal, only one is producing the most widely used grade of ferrochromium (50 to 55 percent charge chromium). 21/ The other four now primarily produce specialty alloys and metals.

20/ These changes are clearly interrelated. U.S. producers have been shutting down capacity largely out of the belief that in the long run they would become increasingly unable to compete with imports on the basis of price. By the same token, potential for imports has expanded as capacity has been eliminated.

21/ Rogers, Jack. Stainless Producers Are Part of the Ferrochrome Price Puzzle. American Metal Market. December 14, 1984. p. 9.

Table VIII:3. Salient Features of the U.S. Ferrochromium Market in Recent Years (thousands of short tons of chromium content)

Year	Domestic Shipments	Imports	Apparent Domestic Consumption	Imports as a % of Apparent Consumption
1970	187	26	195	13
1975	101	180	235	76
1978	112	165	275	60
1979	137	123	260	47
1980	112	158	255	62
1981	91	247	293	84
1982	45	77	134	58
1983	26	163	187	87

(a) Low- and high-carbon ferrochromium only

(b) Apparent domestic consumption = domestic shipments + imports + or - change in stocks

Source: Compiled by CRS from data supplied by the Bureau of Mines.

These trends in import competition and domestic capacity give rise to two observations: (1) the United States seems to be losing whatever comparative advantage it once had in ferrochromium production; and (2) the United States is becoming increasingly dependent on foreign sources of ferrochromium.

The main reason for the decline in the competitiveness of U.S. ferrochromium producers over the last ten years is the tremendous growth in ferrochromium capacity during that period in countries with substantial reserves of chromite. Chromite is the raw material from which low- and high-carbon ferrochromium are processed and constitutes the largest factor in the domestic cost of producing a ton of ferrochromium. In this regard, the United States has not been unique. Over the last two decades, world ferrochromium capacity has been moving away from major consuming countries such as Japan, the United States, and the European Economic Community, and toward major producers of chromite, especially South Africa and Zimbabwe. 22/

The leading non-communist chromite-producing countries are South Africa, Zimbabwe, Brazil, India, the Philippines, Finland, and

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22/ Thomas, Paul R. Issues Affecting U.S. Ferrochromium Import Dependency. Society of Mining Engineers of AIME. Preprint Number 84-108. p. 1.

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Turkey. 23/ Of this group, South Africa is by far the largest producer of chromite: in 1983, it accounted for 27 percent of world chromite production. The second largest non-communist producer that year was Zimbabwe, with a little more than 5 percent of world production. The other five countries accounted for 21 percent of production in 1983. The importance of South Africa and Zimbabwe as producers of chromite is only likely to grow in the future since they hold about 94 percent of demonstrated world chromite reserves. 24/

The United States possesses an estimated 11 million short tons of chromite deposits, but at current prices they cannot be recovered profitably. 25/ Chromite has not been mined domestically in sizeable amounts since 1961. Thus, U.S. producers of ferrochromium are wholly dependent on foreign sources for the ore. South Africa is the principal supplier to the United States: in 1982 and 1983 combined, it accounted for 60 percent of chromite imports.

Most of the leading exporters of ferrochromium to the United States today are also major chromite-producing countries. In 1982 and 1983, the leading exporters were South Africa (44 percent of total imports over the period), Zimbabwe (23 percent), Yugoslavia (12 percent), Brazil and Turkey (5 percent each), and Sweden (4 percent). All but Sweden and Yugoslavia are major producers of chromite.

Comprehensive figures on the growth in ferrochromium capacity since 1970 in major chromite-producing countries are not readily available. Nonetheless, a picture of the magnitude of growth can be sketched on the basis of data on world ferrochromium production by major supplying country in recent years. Such data appear in table VIII:4.

The figures suggest that ferrochromium capacity in major chromite-producing countries has grown substantially since the early 1970s. Excluding the Soviet Union, major chromite-producing countries

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23/ The Soviet Union is the world's largest producer of chromite: in 1983, it produced an estimated 2.7 million short tons, or 30 percent of world production. This ranking is unlikely to last, however, for Soviet production is thought to have peaked, whereas both South Africa and Zimbabwe could vastly expand production within two years--assuming sufficient demand worldwide. The Soviet Union is not included in the discussion here because the United States currently buys little Soviet chromite--around 500 short tons in 1983--and no Soviet ferrochromium.

24/ U.S. Department of the Interior, Bureau of Mines. Mineral Commodity Summaries 1985. Washington, January 1985. p. 33.

25/ Commerce Department. Critical Material Requirements of the U.S. Steel Industry. p. 47.

Table VIII:4. Ferrochromium Production by Principal Supplying Countries in Recent Years (thousands of short tons, gross weight)

A. Major Chromite-Producing Countries

Country	1974	1979	1983
Brazil	42	93	86
Finland	53	54	65
India	17	24	46
Philippines	NA	11	24
South Africa	203	612	640
Soviet Union	203	610	680
Turkey	10	33	33
Zimbabwe	200	220	155
Total:	728	1,657	1,729

B. Countries That Produce Little or No Chromite

Country	1974	1979	1983
France	123	105	20
Italy	44	47	40
Japan	597	403	335
Norway	34	13	9
Spain	24	22	15
Sweden	111	209	208
United States	301	247	20
West Germany	NA	66	45
Total:	1,234	1,112	692
World Ferrochromium Production:	2,045	3,302	2,765

NA--Not Available

Source: Compiled by CRS from data supplied by the Bureau of Mines.

accounted for 26 percent of world ferrochromium production in 1974; for 32 percent of world production in 1979; and for 38 percent of world production in 1983. Total ferrochromium production by these countries in 1983 was nearly double what it was in 1974. South Africa and Zimbabwe are once again the dominant members of this group: in 1983, the former accounted for 61 percent of the group's output and the latter, for about 15 percent.

The figures in the table also suggest that the growth in ferrochromium capacity in major chromite-producing countries since the early 1970s has come at the expense of supplying countries with little or no exploitable reserves of chromite. The major countries in this

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category are France, Italy, Japan, Norway, Spain, Sweden, the United States, and West Germany. Their combined contribution to world ferrochromium supply has been on the wane since the early 1970s: they accounted for 60 percent of world ferrochromium production in 1974, for 34 percent of world production in 1979, and for 25 percent of world production in 1983. These same countries are among the leading consumers of ferrochromium in the non-Communist world. Therefore, they constitute the chief markets for ferrochromium producers in most major chromite-producing countries.

A recent study of the ferrochromium production potential of major non-Communist chromite-producing countries indicates that the recent shift in world ferrochromium supply away from major consuming countries is likely to continue in the next five to ten years. 26/ Boyle and Thomas estimate that South Africa, Zimbabwe, Turkey, the Philippines, India, Brazil, and Finland currently have the capacity to produce 1.360 million metric tons of high- and low-cost ferrochromium, or about 37 percent of world capacity. 27/ South Africa and Zimbabwe--both individually and collectively--dwarf the supply potential of the other five countries combined: South Africa's estimated capacity is 820,500 metric tons and Zimbabwe's, 284,000 metric tons.

Based on possible additions to capacity through 1984, Boyle and Thomas estimate that total ferrochromium capacity in the major chrome-producing countries could nearly double within the next five to ten years. 28/ This projection assumes that worldwide demand would be sufficient to warrant such an expansion, and that each country could supply enough additional chromite from domestic reserves. The noteworthy proposed additions to capacity are 500,000 metric tons in South Africa, 200,000 metric tons in India--which would raise current Indian capacity by a factor of 7.73--and 150,000 metric tons in Zimbabwe. The Indian capacity should be usable by the end of 1985, but the earliest that the proposed South African and Zimbabwean capacity could be built is 1987. 29/ These estimates suggest that, barring prolonged supply disruptions tied to political unrest or natural calamities, South Africa and Zimbabwe are only likely to enlarge their shares of the world ferrochromium market in the next decade.

26/ See: Thomas, P. R. and E. H. Boyle, Jr. Ferrochromium Production Potential in Chromite-Producing Countries. Society of Mining Engineers of AIME. Preprint No. 84-390.

27/ Ibid., p. 5.

28/ Ibid., p. 5.

29/ Based on a telephone conversation with Paul Thomas of the Bureau of Mines on April 9, 1985.

As of the end of 1985, only two of the ten leading chromite-producing nations in the world lack the capacity to melt ferrochromium. They are Madagascar and New Caledonia. Among those countries that refine their chromite into ferrochromium, there is great diversity in the age of their smelting capacity. In Greece and the Philippines, capacity was first installed in 1980. In South Africa, Zimbabwe, Turkey, India, Brazil, and Finland, by contrast, capacity was first installed in the late 1960s and has been expanded considerably since then.

South Africa is the leading seller of ferrochromium in both the U.S. and world markets. Between 1980 and 1983, it accounted for 56 percent of U.S. ferrochromium imports and 43 percent of apparent domestic ferrochromium use. One reliable source estimates that South Africa supplies about one-half of the ferrochromium consumed worldwide today. 30/

This preponderance seems to flow from a distinct comparative advantage in ferrochromium production. More than ever before, international trade in ferrochromium revolves around the cheapest source of supply, and the lowest-cost supplier in the world today is South Africa. South Africa enjoys such a status because it possesses the largest and most economical reserves of chromite in the world. 31/ Chromite tends to be the biggest factor in the production cost structure for ferrochromium, accounting for 30 to 50 percent of variable costs. South Africa's enormous resource base has enabled its ferrochromium industry to grow rapidly and to exploit the economies of scale that exist in the production of lower-grade "charge" ferrochromium. 32/ What is more, all South African ferrochromium producers are vertically integrated, operate plants located close to chromite mines, and mine the coal they use in smelting. 33/

These advantages make it likely that South African producers will be competitive in the U.S. market for a long time to come--assuming, of course, that no barriers are erected to South African imports. Paul Thomas of the Bureau of Mines estimates that South African producers of high-carbon ferrochromium have a long-term cost advantage

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30/ Preece, Howard. It's Boom Time in South Africa. American Metal Market. December 14, 1984. p. 10.

31/ Thomas, Paul R. Issues Affecting U.S. Ferrochromium Import Dependency. p. 1.

32/ Ibid., p. 1.

33/ Crown, Judith. One Company's Battle. American Metal Market. May 25, 1982. p. 9A.

over the most efficient U.S. producers of $0.03 to $0.04 (1981 dollars) per pound of contained chromium. 34/ This estimate includes the cost of shipping the ferrochromium from Durban, South Africa to Pittsburgh. A cost advantage of this size means that, depending on the current market price, South African producers should be able to realize higher profits or suffer lower losses of at least $0.03 to $0.04 per pound of contained chromium sold than their U.S. rivals. In December 1983, prices for domestic 50 to 55 percent charge chromium ranged from $0.40 to $0.43 per pound of contained chromium, compared to a range of $0.39 to $0.40 for the imported variety. 35/

The competitive position of U.S. ferrochromium producers has been further weakened in recent years by the strong rise of the U.S. dollar against the currencies of major ferrochromium-exporting countries. According to data published by the International Monetary Fund (IMF), from the first quarter 1981 through the fourth quarter 1984, the U.S. dollar rose by 58 percent against the South African rand, 55 percent against the Zimbabwean dollar, 3753 percent against the Brazilian cruzeiro, 91 percent against the Swedish crown, 346 percent against the Turkish lira, and 537 percent against the Yugoslavian dinar. 36/ These currency movements magnify the cost disadvantages of U.S. ferrochromium producers.

It should be stressed, however, that the appreciation of the dollar has merely exacerbated the competitive problems of U.S. producers. The root of these problems lies in the shift of comparative advantage away from major consuming countries and to major chromite-producing countries, a shift that began in the early 1970s and has been

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34/ Thomas, Paul R. Issues Affecting U.S. Ferrochromium Import Dependency. p. 2. By "long-term" he means 50 to 70 years.

35/ Bureau of Mines. Preprint from 1983 Minerals Yearbook: Chromium. p. 16.

36/ Appreciations of these magnitudes do not necessarily mean that the average price of imported ferrochromium has declined substantially in recent years. The cost of production has gone up in all producing countries by varying amounts. What is more, domestic market prices are greatly influenced not only by the number of suppliers competing in the market and their cost structures, but also by the state of ferrochromium demand. Some foreign producers may use declines in the value of their currencies against the dollar to bolster profit margins or to cut losses on sales to the United States. According to the Bureau of Mines, in January 1981, the price range for imported 50 to 55 percent charge chrome was $0.45 to $0.46 per pound of contained chromium; in December 1983, the same range was $0.39 to $0.40--which was about 13 percent below the January 1981 price range.

gaining momentum ever since. Imports began to account for more than 50 percent of domestic consumption in the mid-1970s, long before the dollar started its recent ascent.

Ferromanganese

As in the case of ferrochromium, perhaps the major development in the U.S. ferromanganese market since 1970 has been the steady rise in import competition. Imports accounted for 26 percent of apparent domestic consumption in 1970, 46 percent in 1975, 75 percent in 1980, and 91 percent in 1982 (see table VII:5). Domestic ferromanganese producers have responded by closing uneconomic or surplus production capacity. According to the Ferroalloys Association, 78 percent, or some 840,000 short tons of the capacity in existence on January 1, 1973 was shuttered by January 1, 1985.

As in the case of ferrochromium, the trends in import competition and domestic production capacity raise two important policy issues. One is the dependency of the United States on foreign sources of ferromanganese: the United States has clearly become more dependent on such sources since the early 1970s. The other issue is the emerging pattern of international competitive advantage in ferromanganese production: the United States seems to be losing whatever comparative advantage in ferromanganese production it once possessed.

A recent study by the Commerce Department indicates that U.S ferromanganese producers have found it difficult to compete on the basis of price with most foreign producers selling in the United States since the early 1970s. Based on quoted prices, the price of imported high-carbon ferromanganese was lower than the price of the domestic equivalent in all but five of the calendar quarters from 1972 to 1982. 37/ Moreover, declines in the prices of imports always preceded declines in domestic prices.

The leading foreign sellers of ferromanganese in the United States are South Africa, France, Mexico, Brazil, Portugal and Norway. In 1982 and 1983 combined, South Africa accounted for 39 percent of U.S. imports, France for 26 percent, Mexico for nearly 9 percent, Brazil for 7 percent, Portugal for 4 percent, and Norway for 3 percent.

The two biggest factors in the variable cost structure for ferromanganese are manganese ore and electricity. Smelting the ore requires enormous quantities of electricity. Countries with cheap sources of both are likely to possess or develop a comparative advantage in ferromanganese production.

37/ Federal Register. Presidential Decision on the Impact of Ferroalloy Imports on the National Security. p. 21394.

Table VIII:5. Salient Features of the U.S. Ferromanganese Market (thousand of short tons of manganese content)

Year	Domestic Shipments	Imports	Apparent Domestic Consumption a/	Imports as a % of Apparent Consumption
1970	655 b/	227	861	26
1975	454 b/	307	670	46
1978	220 b/	531	792	67
1979	264	639	895	71
1980	155	473	634	75
1981	150	522	664	79
1982	80	384	422	91
1983	88	266	386	69

(a) Apparent domestic consumption = domestic shipments + imports - exports + or - change in stocks.

(b) Domestic production rather than shipments. The Bureau of Mines only began to report domestic ferromanganese shipments in 1979.

Source: Compiled by CRS from data supplied by the Bureau of Mines.

Of the major exporters of ferromanganese to the United States today, South Africa and Brazil are endowed with substantial reserves of high-grade ore, and Norway, Mexico, and South Africa are relatively low-cost suppliers of electricity. Only South Africa falls in both categories, raising the possibility that it may be the lowest-cost producer of ferromanganese in the non-Communist world, or that it has the potential to become so.

The leading non-Communist suppliers of manganese ore are South Africa, Brazil, Gabon, Australia, and India. In 1983, South Africa accounted for 13 percent of world production, Brazil for 9 percent, Gabon for 8 percent, and Australia and India for around 6 percent. 38/ No manganese ore is mined in the United States today. What meager reserves are found domestically cannot be recovered profitably at current prices. All manganese ore processed in the United States, then, has been imported--primarily from South Africa, Gabon, Australia, and Brazil.

Of the leading ore-producing countries, only Gabon has not attempted to capture more of the value-added in ferromanganese

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38/ Bureau of Mines. Mineral Commodity Summaries: 1985. p. 97.

production by investing in processing capacity. All the others have invested heavily in such capacity over the past 10 to 15 years. 39/ In 1983, South Africa accounted for nearly 7 percent of world ferromanganese production, India for 3 percent, Brazil for around 2 percent, and Australia for 1.5 percent.

Not all major suppliers of ferromanganese possess substantial reserves of ore. Some are major consuming countries, and some produce ferromanganese because domestic electricity costs are relatively low. The most prominent examples are Japan (7 percent of world production in 1983), France (6 percent), Norway (4 percent), West Germany (4 percent), and Mexico (2.5 percent).

Future growth in capacity is likely to be concentrated in countries with abundant reserves of high-grade manganese ore or relatively cheap electricity. The strongest candidates are South Africa, Australia, Brazil and Mexico. The Bureau of Mines estimates that South Africa possesses a manganese reserve base of 2.9 billion short tons of managanese content -- about 72 percent of the estimated world reserve base -- Australia a reserve base of 216 million short tons, and Brazil a reserve base of 69 million short tons. Substantial growth in capacity in South Africa over the next 5 to 10 years could strengthen its standing as one of the leading lowcost ferromanganese producers in the world. Norway is also likely to remain a major exporter of ferromanganese to Western Europe and the United States because of its advanced processing technologies and its hydroelectric power. India and Gabon, on the other hand, could be hampered in the future by a lack of relatively cheap electricity. 40/

The competitive posture of U.S. ferromanganese producers has also been undermined by the strong rise of the U.S. dollar against the currencies of major ferromanganese-exporting countries in recent years. If anything, the appreciation of the dollar has accelerated the shift of comparative advantage away from the United States. According to the IMF, from the first quarter 1981 through the fourth quarter 1984, the dollar rose by 58 percent against the South African rand, 84 percent against the French franc, about 700 percent against the Mexican peso, 3753 percent against the Brazilian cruzeiro, about 200 percent against the Portugese escudo, and about 65 percent against the Norwegian crown. These rises explain some of the drop in the price range for imported high-carbon ferromanganese from $400 to $430 per long ton of alloy in 1981 to $310 to $340 in 1983.

39/ Schanz, John J., Jr. Manganese Reserves and Resources of the World and Their Industrial Implications. National Materials Advisory Board. Publication NMAB-374. Washington, 1981. p. 73.

40/ Commerce Department. Critical Material Requirements of the U.S. Steel Industry. p. 93.

Ferrosilicon

Silicon is present in all steels, either as a residual from ore, scrap, or as an alloying element. 41/ Steelmakers use silicon as both an alloying and processing agent. As an alloying agent, it increases tensile strength and improves corrosion resistance and electrical properties. As a processing agent, it removes oxygen from most grades of carbon and alloy steels. In 1983, steelmakers accounted for 56 percent of reported domestic ferrosilicon consumption. Iron foundries are the second largest users of ferrosilicon, accounting for 42 percent of reported consumption in 1983.

Silica is the raw material from which ferrosilicon is produced. It is one of the most abundant minerals in the world, and reserves in major producing-countries are thought to be unlimited. 42/ The United States is self-sufficient in silica and is one of the leading producers of silica in the world. In 1983, the United States accounted for 12 percent of world production; other major producers that year were the Soviet Union (20 percent), Norway (13 percent), France (6 percent), Brazil (5 percent), Japan (4.6 percent), and South Africa and Yugoslavia (4 percent). 43/

Compared to ferrochromium and ferromanganese, the structure of the U.S. ferrosilicon market has changed little since 1970. Imports have not been a major factor, largely because U.S. producers have almost unlimited supplies of the needed raw materials. This is not to suggest, however, that domestic ferrosilicon producers face no challenges from abroad. On the contrary, since 1980, they have become increasingly vulnerable to foreign competition. This is reflected in table VIII:7. The share of apparent domestic consumption accounted for by imports rose from 13 percent in 1980 to 33 percent in 1983.

Despite their comparatively strong competitive posture, domestic ferrosilicon producers have closed substantial capacity in recent years. According to the Ferroalloys Association, nearly 40 percent of the capacity in existence on January 1, 1978, or some 480,000 short tons, was shuttered by January 1, 1985.

Some of this loss can be considered a strategic response to the consolidation that has been taking place in the domestic steel industry since the mid-1970s. 44/ According to the American Iron and

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41/ Ibid., p. 112.

42/ Ibid., p. 118.

43/ Bureau of Mines. Mineral Commodity Summaries. 1985. p. 139.

44/ Botta, Mike. Ferrosilicon Survives in the U.S. American Metal Market. May 23, 1984. p. 4A.

Table VIII:7. Salient Features of the U.S. Ferrosilicon Market (thousand of short tons, gross weight)

Year	Domestic Shipments	Imports	Apparent Domestic Consumption a/	Imports as a % of Apparent Consumption
1970	480	22	426	5
1975	447	70	505	14
1978	607	135	748	18
1979	631	114	722	16
1980	494	71	536	13
1981	450	155	566	27
1982	289	77	365	21
1983	310	159	481	33

(a) Apparent domestic consumption = domestic shipments + imports - exports + or - change of stocks.

Source: Complied by CRS from data supplied by the Bureau of Mines.

Steel Institute, domestic raw steel capacity fell by 10 million short tons between 1977 and 1983. Iron casting capacity has also shrunk in recent years: since 1980, at least 520 iron foundries have gone out of business. 45/ The decline in raw steel capacity alone means that maximum domestic ferrosilicon requirements were about 21,000 short tons less in 1983 than in 1977, at 1983 usage rates.

But some of the drop in ferrosilicon capacity is due to rising import competition. Many domestic manufacturers have shut down furnaces in the belief that a certain share of the domestic market is permanently in the hands of foreign rivals. The rise in import competition can be attributed largely to three factors: (1) sizable increases in U.S. electricity rates since the late 1970s; (2) rapid growth of production capacity in countries with relatively low electricity costs and abundant reserves of silicon; and (3) the sharp rise of the U.S. dollar against the currencies of major ferrosilicon-exporting countries in the 1980s. These factors have eroded the ability of U.S. producers to compete on the basis of price with foreign producers selling in the United States. 46/

45/ U.S. International Trade Commission. Competitive Assessment of the U.S. Foundry Industry. USITC Publication 1582. Washington, September 1984. p. 7.

46/ Rogers, Jack. Ohil Ferro-Alloys Closing Philo Plant Temporarily. American Metal Market. August 15, 1984. p. 7.

Energy in general--and electricity in particular--constitutes a major factor in the variable cost of producing a ton of ferrosilicon. One reliable source estimates that energy accounts for 50 to 60 percent of this cost, depending on the plant's location. 47/ How much a producer pays per kilowatt-hour of electricity used can have a profound influence on its market share. According to the Department of Energy, the average cost of electricity to industrial users in the United States nearly doubled between 1977 and 1983. The rates charged domestic ferrosilicon producers probably rose slightly less since most of them purchase electricity from the Bonneville Power Administration and the Tennessee Valley Authority on the basis of long-term contracts. 48/ Some industry executives speculate that some ferrosilicon plants will be forced to close within the next two years when their contracts expire. 49/

As in the case of other ferroalloys--such as ferromanganese--in recent years ferrosilicon capacity has grown in countries with relatively cheap electricity and relatively lenient environmental protection laws. Countries that are becoming increasingly important suppliers of ferrosilicon are the Soviet Union, Brazil, Iceland, Venezuela, Norway, and the People's Republic of China. 50/ In 1983, the Soviet Union accounted for 24 percent of world production, compared to 18 percent in 1978; Brazil for 5 percent, up from 2.5 percent in 1978; Iceland for 9.7 percent, compared to nothing in 1978; Venezuela for 1.6 percent, versus 1.3 percent in 1978; Norway for 11 percent, up from 9.6 percent in 1978; and the People's Republic of China for 6.5 percent, compared to 2.6 percent in 1978.

Many of these countries are among the leading exporters of ferrosilicon to the United States. In 1982 and 1983 combined, Brazil accounted for 25 percent of U.S. imports, Venezuela for 14 percent, Norway for 18 percent, and the Soviet Union for 7 percent. Other major foreign suppliers are Canada (17.5 percent of U.S. imports in 1982-83), France (5.7 percent), and the Federal Republic of Germany (2 percent).

The appreciation of the dollar against the currencies of major ferrosilicon-exporting countries since 1980 has also boosted the competitiveness of imports in the U.S. ferrosilicon market. The

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47/ Commerce Department. Critical Material Requirements in the U.S. Steel Industry. p. 123.

48/ Ibid., p. 123.

49/ Ferrosilicon Survives in U.S. American Metal Market. p. 414.

50/ Commerce Department. Critical Material Requirements of the U.S. Steel Industry. p. 118.

rise of the dollar explains at least part of the decline in the average quoted domestic price of 50 percent ferrosilicon from $0.4925 per pound of contained silicon at the end of 1981 to $0.4300 at the end of 1983, a drop of nearly 13 percent.

A recent Commerce Department study contends that future growth in ferrosilicon capacity will be concentrated in less developed countries with lower energy and labor costs and less stingent environmental protection laws than the United States. Furthermore, the study suggests that capacity in most advanced industrial nations, including Japan, France, West Germany, and the United States, should level off or decline by 1990. From 1980 to 1990, the greatest growth in capacity is projected to occur in the Soviet Union (an additional 100,000 short tons), followed by Brazil and South Africa (70,000 short tons), the People's Republic of China (65,000 short tons), Iceland (50,000 short tons), and Norway (35,000 short tons). 51/

51/ Ibid., p. 133.

IX. THE FACTORS THAT DETERMINE COMPETITIVENESS IN MINING*

A. Introduction

Those who had grown accustomed to the U.S. preeminent position in world mining were perhaps not fully prepared for the Business Week cover story in late 1984 entitled, "The Death of Mining". 1/ In this vein, it is appropriate to recall the message from Mark Twain to the Associated Press that "The reports of my death are grossly exaggerated". Nonetheless, the long struggle of the steel industry and the confirmation by the U.S. International Trade Commission that the copper mining industry was indeed being harmed by competition gave credence to this observation. It appeared that the mining sector had joined the automobile industry and other sectors as declining bastions of U.S. industrial potency. In fact, although the decline is real and substantial, the U.S. mining industry when viewed in its totality and from the proper perspective still places the United States in an enviable position among the world's industrial nations.

For those who follow mineral affairs closely, it had become rather obvious for some time that in a number of instances other nations were overtaking the United States in their ability to produce and compete in world mineral trade. The number of commodities for which the United States was the leading producer had shrunk. In some cases, this reflected a relative decline, in others an absolute drop in U.S. output. This was not a sudden event but an evolutionary process to be expected to happen in a maturing, extractive industry. Our trade bill for raw minerals, semi-fabricated materials, and manufactures began to grow. U.S. mineral exports had diminished long ago.

The objective here will be to bring together the information in the preceding seven individual mining and processing chapters into a composite picture of the factors that contribute in large and small ways to the vitality of a mineral producing nation in international competition. From this we can gain an appreciation of what internal and external factors have had major leverage in the events that have adversely affected the U.S. mining sector.

1/ Business Week. December 17, 1984. pp. 64-70.

*Prepared by John J. Schanz, Jr., Senior Specialist, Energy and Natural Resources.

B. Natural Advantages

It is well to recall once again the difference between comparative advantage as viewed by the economist and the benefits that flow from the natural endowments possessed by a nation. Comparative advantage in an economic sense incorporates both an internal as well as an external perspective. Under the assumption of free trade, a nation will be economically better off it if concentrates on producing what it does best compared to the rest of the world. The reward from doing this is that a nation can then trade effectively by using the returns from the sale of its comparatively lowest cost products to buy the goods produced more efficiently by other nations. It is conceivable, of course, that one particularly endowed and productive nation could find itself able to produce everything more cheaply than any other nation in the world. But given that no nation has an unlimited capability to produce goods and services, choices have to be made as to what to produce and what not to. Internally, the best choice is to choose among the array of comparative advantages possessed to find the mix that has the greatest aggregate return. Likewise, other countries will make a similar evaluation, relying on international trade to provide those goods that they cannot produce profitably themselves.

A nation which begins making its choices among those economic activities based on comparative advantages will find its natural endowment important in that decision process. The United States found as it entered this century and became a member of the industrial nations of the world that its natural endowments far surpassed those of other industrialized countries. The industrialized nations in Europe were geographically much smaller than the United States and had been mining their mineral resources for much longer.

The North American continent, and particularly the U.S. portion of it, was a uniquely rich and diverse geologic environment. With the exception of what is contained in the vast expanses of the Soviet Union, no other nation to date has found such a combination of variety, quality, and quantity within its boundaries. This, of course, may change in the future based on explorations and events yet to occur. Through its economic history, the United States has prospered from the coals of the East, the petroleum of the Gulf, the high grade iron ores of the Great Lakes, and the base metals of the west. In each case, the deposits at their peak of importance were among the finest that had ever been discovered in the world up to that point. The deep, thin beds of coal in Britain or the brown coals and iron ores of Germany did not compare. Coupled with the metals and fuels were also vast tonnages of industrial minerals and rocks. The notable deficiencies -- such as tin, diamonds, or manganese -- were dwarfed by what the United States actually did possess.

For 100 years a well-educated, skillful population was able to employ those natural endowments in a fashion which parlayed this comparative advantage into the highest per capita income decade after decade. But deposits and fields do become exhausted, new deposits are found in other countries, and comparative advantages shift. One must now examine closely if the metals and energy resources are now a less important component of the U.S. comparative advantage. If so, why is this the case, and what does this portend for future U.S. policy?

C. The Discrete Factors

All other things being equal, the nation possessing the largest, most shallow, and highest grade mineral deposits will be the lowest cost producer and will occupy a position on the supply curve where it is the last to feel the pinch of recession and profits the most when the business cycle reaches it highest peak. Nonetheless, the quality of a mineral deposit and the cost of delivering its output to market is not merely a reflection of grade. The fact that the United States sometimes mined a lower average grade of ore than other countries was in a real sense a reflection of American technical proficiency rather than the poor quality of its deposits. U.S. firms were actually capable of mining a lower grade of ore and still making a return.

In addition to the grade of ore and the percentage of mined material that is recoverable metal, the geological characteristics of that metal can be important. Beneficial attributes include constituents that facilitate the smelting and refining process, or byproducts, which if recovered, can be sold. Similarly, compounds or elements which make the material hard to process or which generate pollution can add significantly to production costs; for example, the presence of silica in bauxite or sulfur discharged into the atmosphere from a copper smelter.

Beginning with the bronze age, the production of metals and their alloys has been most readily accomplished through the use of heat. The metals industry, as a result, tends to be energy-intensive. The United States -- which ranks among the world's three leading possessors of coal, which became the first major center of petroleum production, which possesses a fair amount of hydroelectric power potential, and which became the world's first nuclear power -- did not originally lack in having a clear advantage in terms of readily available and cheap energy with which to produce metals from its mineral reserves.

Thus, we can observe that for most of this century, in terms of the economically important factors of land (i.e., resources), labor, and capital, the United States possessed an enviable advantage in its land and natural resources. Its labor force also became recognized for its skill and efficiency. The output of metal per man was high and even when wages increased, the unit labor cost remained competitive. Innovation, technology, and management were pursued with zeal and imagination reflecting social and pecuniary reward.

Following an initial input of foreign capital in the nineteenth century, the United States soon began to generate its own supply of internal capital. The wealthy, the man-on-the-street, and the financial institutions were all willing to provide venture capital. In the extractive industries firms relied heavily on recycling earnings back into the corporate investment stream, and profits were not distributed to equity shareholders but were reinvested and used to expand the future of U.S. mining. Historically then, capital was abundant, the immediate cost of the funds was low, and the restraints of funded debt were avoided. In addition, since other segments of American industry were also performing well, capital goods needed for mining were available domestically and were low in relative cost.

There were other factors working to the advantage of U.S. industry. Access to capital and labor, and the quality of mineral deposits and the mining process itself, are important. But access to the mine site and distance to the market are also important. From its inception, the United States had encouraged both the settlement of its open lands and the development of transportation infrastructure. As a consequence, it was rare for a mineral discovery of any size or quality to be viewed as not producible because of lack of access. Since the world's best customers for raw materials and manufactures were found within U.S. borders, the mine output did not have far to go to find its markets. Forms of American transport were also efficient, often benefiting from government's involvement in the construction and operation of the system, and in some cases the rates charged were intentionally low so as to encourage the growth of industry.

As the years passed, the American mining, processing, and semifabrication process became fully integrated, operating on an internal transfer cost basis rather than in open markets with their intermediate prices and profit-sharing. Income from byproducts was garnered when it was there to be had, but this income was not necessarily crucial to the viability of most mining operations. Primary producers who had to compete against byproduct output from complex ores did not normally expect that byproduct production could exercise so strong an influence in the marketplace as to cause primary producers to shut down.

Inflation was essentially nonexistent in the United States but was seen as something that happened elsewhere when weak governments "ran the printing presses" too long. The dollar was viewed as "strong" and in an era of fixed exchange rates currency fluctuations were unknown. Government was a source of a cost because it levied taxes, but mining was not singled out for extra burdens and was sometimes favored by government. The burden of social costs such as workers welfare and environmental protection were minimal through most of the prosperous years of American mining. Likewise, regulations concerning safety and other matters were not very intrusive or costly, nor some reflect, adequate.

D. The Shift From Advantages to Disadvantages

A large number of identifiable factors were discussed in the above section as contributory to the success of the U.S. mining sector. Despite cycles of boom and bust, inherent to mining, there were many mining companies that proved to be commercial successes in the longer-term. The companies did have tax burdens, paid higher hourly wages per man than did overseas producers, and some mines did not necessarily have high grade, low-cost operations. But on all other counts, the United States had either a clear advantage or at least no disadvantage compared to its competitor mineral-producing nations either when exporting to foreign markets or in battling for sales in the U.S. market. The advantageous and profitable status of the U.S. mining industry that characterized most of the twentieth century persisted to the mid-1970s.

Nonetheless, many of the famous U.S. pits and mines, like those that extracted direct shipping iron ore at Mesabi, in Minnesota; copper at Butte, Montana; lead from the Coeur d'Alene in Idaho; zinc from Gilman in Colorado; or molybdenum at Climax, Colorado, are no longer "modern", have been put up for sale by their owners, or are closed. Exploration has continued in the U.S. and new mines have been opened over the past two decades. But exploration, in many cases by multinational American firms, has spread across the world into Africa, South America, Asia, and the vast reaches of the Pacific Basin. Here have been found deposits equivalent to or better in size or quality than those now operating in the United States.

These newcomers to the international mining and processing industry function in a different world than that which existed during the emergence of the U.S. mining industry. Owing to the relative youth of these mines, mine design and capital equipment is reflective of up-to-date methods. New advances are quickly adopted overseas so there is little opportunity for the United States to have or to retain for very long any form of superior methodology or capital goods. This, of course, does not suggest that the United States cannot achieve greater efficiency by superior performance of its management and work force. Increasingly, however, this must be achieved in fierce international competition.

As was seen with all the base metals examined previously, the United States still demonstrates a high level of real output per man per year. In the absence of superior equipment or the heavy use of low-cost energy, however, this advantage can largely be offset by the lower prevailing wage rates found in most competitor mining countries. The United States is still capable of producing very low-cost coal because of its large, thick, shallow beds of coal. But coal only provides a fraction of the U.S. energy supply, and because it is mostly used by electric power plants which convert it to electricity through an inefficient process, it does not end up as low-cost power. U.S. petroleum and uranium resources are generally viewed as medium-to-high cost, and the best of U.S. hydroelectric power sites have been developed.

The Federal Government does not currently seem inclined to target the mining industry for additional special benefits in taxation. In fact, the Congress is currently considering tax reform legislation that would remove tax benefits such as mineral depletion allowances that are directly targeted at the mining industry. Any future tax incentives seem likely to be part of an industry-wide package rather than specific aids to the mining sector. Environmental regulation to prevent environmental degradation has been adopted as a national, socially desirable objective. While there may be sensitivity to the economic impact this has on the competitiveness of the affected industry, only in a few instances has this concern taken precedence over the commitment to protect the environment. This is also true in other areas of social concern -- workers' economic welfare, workers' rights, and workers' public health and safety. In many cases regulations in these areas have not been enacted with the mining industry specifically in mind, but were adopted as part of a larger panopoly of federal social welfare legislation.

As soon as the U.S. mining industry no longer held a number of natural and technologic advantages, and was also required to make expenditures to be in congruence with various social goals sought in the United States, it generally migrated upward in its position on the world cost curve. More and more firms and mines became "average" or "marginal" in cost and thus were more vulnerable to swings in business conditions or the appearance of new competition or changing circumstances. Thus, a competitor primary producer which benefits from an increase in byproduct prices, or the "price-taking" byproduct producers competing with our primary producers, can survive in a tight market. Downstream integration of processing by the newer producing nations makes additional inroads into the ability of the United States to compete.

Perhaps most injurious to the U.S. mining industry has been the appearance of new features of the international market. One new development is the rise of government-operated or controlled facilities in the 1970s and their behavior. Export earnings, jobs, and other objectives influence the decisions to produce, to expand, to aid, or burden these foreign mining operations. These goals are in considerable contrast to those of a private sector mining industry whose members sought to meet stockholder objectives, to honor their funded debt interest obligations, and to finely tune their output and capacity to expected market needs and shares. A certain uniform behavior by suppliers was tacitly expected, and except for firms aggressively trying to expand market share, usually occured within reasonable bounds.

Another new characteristic of the international market is the wide divergence in regulatory regimes. For a number of metals produced in the United States, but not all, the cost of compliance with environmental regulations has been a burden. The fact that many competitors in the world do not have comparable or similar obligations in terms of environmental protection or worker welfare becomes a more critical concern to today's domestic mining industry than it might have in the past. The diminishing intensity of demand for metals in the American economy removes market growth as a solution. Also, as new markets develop in the Third World, the U.S. market becomes relatively less important and the U.S. mining industry finds itself less advantaged by proximity to the world's biggest market, but finds that new low-cost foreign producers are capable of penetrating it.

Finally, three external economic or institutional forces enter into the picture which are not directly a part of mining and processing per se but have been major contributors to the current conditions of the U.S. mining industry. One is worldwide inflation. Each country, including the United States, pursues different strategies to lower or to adjust to its internal rates of inflation. If a foreign mine is roughly comparable to a U.S. mine in all respects, except for its labor force, the United States is frequently dependent upon its workforce being more productive in order to remain competitive. This is necessitated by the fact that, given the lower standard of living in many developing countries and local wage rates keyed to that standard, the U.S. producer must work more efficiently. As was specifically described for several of the metals discussed previously, however, if that hourly or annual wage is constantly subject to modification by deflation in local currencies the foreign producer is in real terms reducing his local cost of labor. The productivity of U.S. workers in the short-term cannot rise sufficiently fast to compensate for this decline in real foreign labor costs.

A second factor is exchange rates. The cost of a foreign-produced material when imported into the United States, and whether the seller receives a profit from a sale at current U.S. prices for that commodity, is, of course, dependent upon what he had to expend in the way of resources to produce it. If foreign costs were incurred in U.S. dollars we could judge whether or not the U.S. producers have a truly competitive posture. Instead, the return to the foreign seller is affected by exchange rates which do not necessarily reflect real costs, but rather reflect conditions in the international financial markets. A strong dollar will make U.S. metals more expensive and imported foreign metal output cheaper regardless of what might be real expenditures on the factors of production.

Finally, there has been the growing role of multilateral and private financial institutions as sources of capital, with the resultant impact on the cost of capital, and the terms of repayment. The larger private banks, including those of the United States, have entered aggressively into the lending of funds to a number of developing nations who are heavily dependent upon the returns from their natural resources. The large international institutions, such as the World Bank or International Monetary Fund, have, in the process of facilitating economic development, lend funds to countries which either directly or indirectly may affect their ability to develop and maintain mining and processing capacity. These sources of capital are usually at market rates, but even so, two advantages do accrue to foreign mining firms from these lending sources. One, the availability of capital is often relatively greater for a developing country mining firm because mining stands out as an investment opportunity in the Third World. For U.S. mining firms, however, the wide availability of other, often more profitable, investment opportunities means that capital does not flow so easily to mining investments. Two, a state-owned firm can leverage a much greater share of its total value to raise new funds, than can a publicly held firm responsible to its stockholders.

E. Summing Up

There are some twenty identifiable factors of significance in determining the relative strength or weakness of the U.S. metals sector in international competition. Retrospectively, at mid-century the United States found most of these working in favor of the U.S. metals industry while others were neutral or not important at that time. The United States even at mid-century was frequently mining comparatively lower grade ores at some sites, but this was reflective of the capability of U.S. producers to operate at lower grades and still be profitable under the market structure existing at the time. Generally speaking, the most important cost factor that the U.S. mining and processing sectors had to overcome compared to its foreign counterparts was the hourly cost of labor.

When we turn to the situation faced by the U.S. metal mining and processing sector in the early 1980s we find a dramatic change. Many of the factors which had been beneficial for the United States became less so or were negated. One prime example has been the rising cost of energy. With regard to technologic superiority, the competitive edge, which the United States may have had 35 years ago is now dulled by the rapidity of technology transfer.

Each commodity and each mining operation can point to the set of factors which are most important to it and make the key difference between failure, survival, or success given today's market and stagnant growth in demand. Thus, generalization can be misleading. Nonetheless, the negative features that have perhaps been most influential since 1980 in placing the U.S. metals industry in a weakened competitive position are:

- °An unavoidable decline in the relative quality of our remaining natural endowment in mineral and fossil fuel resources relative to those which are or will become, available from the less depleted areas of the world.
- °The continuing necessity to compensate for the higher cost of a labor force drawn from a population with a high standard-of-living.

- °The market impact of inflationary adjustments abroad and favorable exchange rates which enable foreign producers to gain greater access to domestic markets.

Two other factors which also add a burden to U.S. industry but are not necessarily, by themselves, sufficient to have caused the domestic industry to become non-competitive are:

- °The availability of capital to foreign operations and the differing production objectives of foreign governmental operations compared to that of the U.S. private entities.
- °The incremental cost burden placed on U.S. mining firms under environmental and other regulations compared to that borne by most competing foreign operations.

The United States does still in many cases operate at an advantage over some foreign operations and certain countries with respect to:

- °The net tax burden or other payments to government by the mining sector.
- °The cost of transportation from mine to market destination.
- °The contribution of byproduct credits to the mining income stream; while some U.S. producers with no byproducts suffer from the impact of overseas byproduct output, those U.S. producers with byproducts realize a real gain.

The one element in the equation which remains the major positive factor in the United States by which the mining and processing sectors combat foreign competitive disadvantage is:

- °The high level of productivity of the workforce in general when measured in terms of refined metal output per annum.

The key factors identified above are examined individually and in-depth in the next section.

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X. AN EXAMINATION OF THE KEY FACTORS AFFECTING COMPETITIVENESS*

A. Introduction

The previous section has drawn upon a review of seven domestic metal industries to identify the many factors which have minor or major influence in determining the relative strength of the U.S. mining industry in international trade and within domestic markets. How these factors rank in significance varies from one commodity to another. How well each segment of the mining industry is currently faring, and the degree of contemporary concern either within or without the industry is also not uniform.

It is apparent that there are four major elements in the determination of how well or poorly a U.S. metal mining and processing industry performed in the first half of the 1980s. These are:

1. The effect of movements of exchange rates on prices and on the costs incurred by foreign producers.
2. The real level of the average cost of mining in the U.S. and the variation among mines.
3. The real cost of capital to U.S. competitors and how that capital may often be employed to meet national goals, as compared to standard business practices in the U.S.
4. The net mix of special burdens and benefits resulting from government policies in the U.S. versus those experienced by mining competitors abroad.

These four topics will be examined in greater depth in this section.

B. The Impact Of Exchange Rates On Metals Prices And U.S. Cost Competitiveness*

Exchange rate changes may affect the competitive position of the United States in metals through two main channels. (1) A change in real (inflation-adjusted) exchange rates between the United States and the major metals consuming countries will affect the demand for, and consequently, the price of metals. (2) If real exchange rates between the United States and major metals producing countries change, U.S. cost competitiveness relative to the other producing countries will also change.

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*Prepared by Arlene Wilson, Specialist in International Trade and Finance.

Background on Exchange Rates

Exchange Rate Arrangements. From 1945 to 1973, exchange rates among countries were fixed, in accordance with the agreement reached at Bretton Woods, New Hampshire in 1944, which also established the International Monetary Fund (IMF). The fixed exchange rate system worked reasonably well until the late 1960s when U.S. balance of payment deficits became large and speculation against the dollar became severe. Consequently, fixed exchange rates were abandoned in March 1973, and each country now determines whether its currency will be fixed, floating, or some variant of the two.

The current system is termed the "floating (or flexible) exchange rate system" even though only relatively few countries allow their currencies to fluctuate freely. At the end of February 1986, of the 149 IMF-member countries, 93 pegged their currencies to the U.S. dollar, another currency, or a basket of currencies. 1/ Thirteen countries permitted limited flexibility, including the eight countries that participate in the European Monetary System (EMS). 2/ Of the 42 countries whose currencies are more flexible, only 17 float independently.

Causes of Exchange Rate Fluctuations. Exchange rates among floating currencies are determined mostly by the supply and demand for currencies. For example, if the demand for dollars in the foreign exchange market is greater than the supply, the dollar will appreciate (that is, buy more units of a foreign currency). The demand for dollars in the foreign exchange market is derived primarily from payments by foreigners for U.S exports and from foreign capital flows to the United States (such as direct investment by foreigners and foreign bank deposits in the United States). Similarly, the supply of dollars arises from payments to foreigners for U.S. imports and from capital

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1/ International Monetary Fund. International Financial Statistics. April 1986, p. 18. There is no currency information for one of the IMF-member countries.

2/ The EMS is a monetary arrangement in which each country maintains the value of its currency in relation to that of the other participating countries but float freely against other currencies. The participating members are Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg and the Netherlands.

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flows from the United States to foreign countries. Central banks, such as the Federal Reserve System, can intervene in the foreign exchange market (by buying or selling foreign currencies) to affect exchange rates. If intervention is substantial, it is termed "managed floating".

Among the major industrial countries, exchange rates have fluctuated considerably more than had been anticipated when the floating exchange rate system became effective in 1973. For example, between year-end 1980 and year-end 1984, the dollar appreciated 60 percent against the Deutsche Mark (DM), 113 percent against the French franc, 107 percent against the British pound and 24 percent against the Japanese yen. On a trade-weighted basis, however, the dollar appreciation was considerably less -- about 41 percent over the same period. 3/

Since February 1985, when the dollar reached an all-time high, it has depreciated substantially against some of the major currencies. For example, between February 1985, and February 1986, the dollar depreciated 31 percent against the yen, 33 percent against the DM, and 18 percent on a trade-weighted basis. However, over the same time period, the dollar depreciated 3 percent against the Canadian dollar.

The causes of the 1980-84 dollar appreciation are not well understood. In the long-run, most analysts agree that exchange rates move to offset relative inflation rates (purchasing-power parity) so that real exchange rates remain constant. In the short and medium term, however, exchange rates have fluctuated more than has been warranted by differences among countries in relative inflation rates in recent years. For example, in real terms, the dollar has appreciated 35 percent against a trade-weighted average of fifteen currencies between the end of 1980 and 1984. 4/

In the early 1970s, when capital flows were small and often restricted, it was thought that exchange rates were determined mainly by trade flows. Trade flows, in turn, were thought to be determined primarily by prices in the United States relative to foreign prices, and the level of economic activity in the United States relative to economic activity abroad. For example, a recession in the United States, other things being equal, leads to fewer imports, an improvement in the trade balance, and dollar appreciation. Also, a decline in U.S. prices, other things being equal, leads to higher U.S. exports and fewer U.S. imports, an improvement in the trade balance, and dollar appreciation.

3/ Based on Morgan Guaranty's trade-weighted index of the dollar against 15 major currencies.

4/ Based on Morgan Guaranty's nominal effective exchange rate adjusted for differential inflation in wholesale prices of nonfood manufactures.

In recent years, however, capital flows have increased substantially and most analysts believe they are an important, and perhaps the major, factor in the determination of exchange rates, at least in the short-run. Based on balance of payments data, net capital inflows into the United States were about $100 billion in 1984.

An underlying, and perhaps the most important, cause of large capital inflows was the mix of tight monetary and loose fiscal policy in the United States, which led to high interest rates. Other factors that probably contributed to large capital inflows were the perception of the United States as a "safe haven" and the excellent economic performance, especially the low inflation rate and high profit potential of investment, of the United States.

Effects of Exchange Rate Changes. Exchange rate changes have wide-ranging direct and indirect effects on domestic economies and international trade. Perhaps the two most important direct effects are on the rate of domestic inflation and on international trade flows. For example, since 1980, dollar appreciation contributed to the relatively low rate of U.S. inflation and to the high U.S. trade deficit. Among the many indirect effects, exchange rate changes may stimulate speculative international capital flows, lead to monetary policy changes, and increase demands for protectionism. This study focuses, however, on the effect of exchange rate changes on metals prices and on U.S. cost competitiveness.

Exchange Rates and Metals Prices

One important way in which exchange rates affect commodity prices is through a shift in demand in the consuming countries, most of whose currencies fluctuate against the dollar. For simplicity, the way in which this occurs is described for two countries, the United States and Germany. Under certain assumptions, an appreciation of the dollar against the DM causes the DM price of imported metals to rise. 5/ If other things (such as the price of substitute goods) remain the same, the real price of imported metals in Germany rises. According to economic theory, a rise in real prices causes the amount demanded of a good to decline. Consequently, world demand for metals declines, causing a decline in the dollar price as well as in the supply of metals. The amount by which the price declines will depend on the amount by which the exchange rate changes, the elasticity of supply, and the importance of Germany in world consumption of the metal. 6/ The larger the exchange rate change, the smaller the

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5/ The main assumptions are that markets are competitive (with many buyers and sellers) and the commodity is homogeneous. These assumptions apply reasonably well to the metals market.

6/ The elasticity of supply is the percentage change in the quantity supplied as a proportion of the percentage change in the price.

elasticity of supply (which will likely be low in the short-run), and the larger Germany's share of metal consumption, the larger will be the effect on the price of metals.

From 1980 to 1984, the price of metals declined at the same time as the dollar has appreciated (raising the foreign currency price of metals). However, many other factors have had an effect on metals prices over this period, such as world economic activity and the level of metals stocks. Without analyzing these other factors as well as the complex exchange rate relationships and trading patterns among countries, which is beyond the scope of this study, it is not possible to estimate how much of the decline in commodity prices can be attributed to exchange rate changes. Some idea of the magnitude of this effect, however, can be found in a recent econometric study. Chu and Morrison found that, with respect to the exchange rate, the elasticity was 1.4 for all commodity prices and 1.9 for the price of metals from 1972 to 1982. 7/ Moreover, they concluded that exchange rates had a larger effect on commodity price declines in the 1981-82 recession than in the 1975 recession. 8/

The volatility of exchange rates may also affect the price of metals. It is possible that metals are bought as a hedge against currency fluctuations when these fluctuations are severe. In other words, an increase in currency fluctuations increases the demand, and thus the price, of metals.

According to one author, there is evidence that, in 1976, copper was bought as a hedge against the depreciation of the British pound, and contributed to the rise in copper prices in that year. 9/ In another study, Grilli and Yang estimated econometrically the effect of exchange rate instability, along with other factors, on commodity prices. They found that exchange rate instability was positively related to commodity prices (and especially to metals prices). 10/

7/ Chu, Ke-youn and Thomas K. Morrison. The 1981-82 Recession and Non-oil Primary Commodity Prices. IMF Staff Papers, v. 31. March 1984. pp. 111-112. Both of these elasticities were statistically significant at the 99 percent level.

8/ Ibid., p. 126.

9/ Mikesell, Raymond F. The World Copper Industry. Baltimore. The Johns Hopkins University Press, 1979. p. 93.

10/ Grilli, Enzo R. and Maw-cheng Yang. Real and Monetary Determinants of Non-oil Primary Commodity Price Movements. In Distribution, Effective Demand and International Economic Relations, edited by J.A. Kregel. New York. St. Martin's Press, 1983, pp. 135-138. The relationship between exchange rate instability and metals prices was positive, greater than one, and statistically significant at the 90% level.

Exchange Rates and Cost Competitiveness

As illustrated in the discussions of copper, lead, zinc, and iron ore, U.S. cost competitiveness vis-a-vis foreign producers of metals can deteriorate if the currencies of foreign producers depreciate (or are devalued) against the dollar. Likewise, cost competitiveness can deteriorate if U.S. costs rise faster than the costs of competitors. Generally, a currency depreciation of foreign competitors which is offset by an increase in foreign costs relative to U.S. costs will have no effect on U.S. cost competitiveness. Stated another way, if real exchange rates among countries do not change, U.S. cost competitiveness vis-a-vis other countries will not change.

Table X:1 recapitulates the consumer price index behavior observed in the United States, Chile, and Peru. Although the Canadian consumer price index rose faster than that in the United States since 1980, there was very little difference in U.S. competitiveness with respect to Canada after adjusting for exchange rate changes through 1984. In 1985, however, the appreciation of the U.S. dollar against the Canadian dollar about 5 percent more than offset the slightly larger price increases in Canada, worsening U.S. competitiveness vis-a-vis Canada.

Table X:1 Consumer Price Indexes for the U.S., Canada, Chile and Peru (1980 = 100)

Year	Consumer Price Index in Domestic Currencies			Consumer Price Index in U.S. Dollars			
	Canada	Chile	Peru	United States	Canada	Chile	Peru
1980	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1981	112.4	119.7	175.4	110.4	109.7	119.7	120.1
1982	124.6	131.6	288.4	117.1	118.1	100.8	119.4
1983	131.8	167.4	609.0	120.9	125.0	82.8	108.0
1984	137.5	200.7	1280.2	126.1	124.1	79.3	106.7
1985	143.0	262.3	3372.0	130.5	122.4	63.5	88.8

Source: Computed by CRS based on data in International Monetary Fund, International Financial Statistics, April 1986, pp. 142, 144, 152, 388, and 504.

Prices in Chile rose considerably faster than in the United States but, when adjusted for exchange rate changes, U.S. competitiveness with respect to Chile deteriorated considerably. Compared with the U.S. consumer price index of 130.5 in 1985, the exchange-rate adjusted index in Chile was 63.5. In other words, the Chilean peso was devalued far more than was necessary to offset the rise in relative inflation rates. In fact, of the three countries, U.S. competitiveness against Chile has worsened the most since 1980.

In Peru, prices rose dramatically since 1980; by 1985, prices were more than thirty-three times their level in 1980. After adjusting for exchange rate changes, however, the consumer price index in Peru was 88.8, compared with 130.5 in the United States. Again, as in the case of Chile, currency devaluations in Peru more than exceeded the difference in the relative inflation rate between Peru and the United States. Although U.S. cost competitiveness vis-a-vis Peru worsened, the deterioration was less severe than in respect to Chile.

In summary, since 1980, exchange rate changes led to a decline in U.S. competitiveness against both Chile and Peru, although the decline was more severe with respect to Chile. Although prices in Canada rose faster than U.S. prices, exchange rate changes did little more than offset changing relative domestic prices through 1984, but the appreciation of the U.S. dollar worsened U.S. competitiveness vis-a-vis Canada in 1985.

Policy Options and Actions

Since it appears that exchange rates have contributed to the decline in metals prices and the deterioration in U.S. cost competitiveness, policy options to reduce the dollar's appreciation may be of interest. These options apply mainly with respect to other floating currencies; the United States has very little influence over exchange rates of countries that adjust their currencies according to a set of indicators, such as Chile and Peru.

Probably the most effective option is to relax U.S. monetary policy and tighten fiscal policy, both of which, it is argued, will lower U.S. interest rates and reduce capital inflows, causing the dollar to depreciate. More broadly, coordination of macroeconomic policies among the major industrial countries would likely result in smaller interest rate fluctuations, fewer international capital flows, and a more stable exchange rate.

Another option is for the Federal Reserve and foreign central banks to intervene more forcefully in the foreign exchange market. Most studies have shown that intervention is ineffective, except in the very short-run, in affecting exchange rates. Some observers argue, however, that if intervention is a credible signal to the foreign exchange market of future government policies, intervention might be effective.

Between 1981 and 1984, the United States had a "hands-off" policy towards the dollar, but this policy changed in 1985. On September 22, 1985, the United States participated in the G-5 agreement, in which the United States, the United Kingdom, Germany, Japan, and France announced that they would cooperate to achieve exchange rates that better reflected the fundamentals. This agreement, which was widely interpreted to mean a joint effort to lower the value of the dollar, was followed by foreign exchange intervention, tighter U.S. fiscal policy and a more restrictive Japanese monetary policy. Many analysts claim that the G-5 agreement was a major factor in the dollar's depreciation since September 1985.

C. Production Cost Elements*

It is clear from the individual industry analyses that the major factors determining production costs of metals in a country -- thus affecting competitiveness -- are the quality of the ore deposits, energy costs, rates of labor compensation, and labor productivity. In some cases, laws for environmental protection impose significant additional costs. In addition, sometimes the particular location of ore deposits and processing facilities and the relative cost of available transportation significantly affect the competitiveness of delivered materials.

Ore Quality

In nearly all the cases examined, U.S. metal ore deposits are poorer in one respect or another than those worked by most of the chief foreign competitors of U.S. producers. For example, copper ore in U.S. producing surface mines averaged 0.67 percent copper content (by weight) in 1981, compared with 1.02 percent, 0.79 percent, and 4.05 percent in Chile, Peru, and Zaire, respectively. Taconite ore (on which U.S. iron mining is now almost entirely dependent) contains only 22 percent iron, compared with a worldwide average of 25 to 35 percent, and up to 65 percent for enriched hematite deposits in Brazil and Venezuela. U.S. zinc ores have only one-third to one-half the metal content of ore deposits worked by foreign producers.

In some cases, high concentrations of undesirable components, such as silica, effectively decreases the quality of a metal in terms of ease of processing. For some metals, U.S. ores are unsuitable because of low grade or quality, or they are essentially not available in the U.S.

U.S. ores often are poor or unsatisfactory because of many years of extraction of the better grades (as in the cases of copper and iron), or because the country's original endowment of those minerals was meager or lacking (as in the cases of bauxite, chromite, and manganese). In addition to depletion of higher quality ores, mining over an extended period in the United States has led to a marked increase in the ratio of waste rock to ore removed in metal mines. That ratio has risen about 60 percent during the last 20 years. 11/

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*Prepared by Bernard A. Gelb, Analyst in Industry Economics.

Other thing being equal, mining and processing of more waste and of lower grade ores entails the handling of larger quantities of materials (rock, ore, and concentrates), and more difficult beneficiation, smelting, and refining operations. These characteristics require the use of more energy and labor, and of additional and more complex capital equipment. For example: (1) The mining and beneficiation of ore containing 0.6 percent copper (approximately the U.S. average) uses about 30 percent more energy per pound of copper content than ore containing 1.0 percent copper (approximately the foreign average), according to one engineering analysis. 12/ (2) As seen in the previous chapter on iron ore, because iron is so finely dispersed in taconite, the ore must be ground extremely fine in order for the iron to be concentrated by magnetic separation, and then the concentrate must be agglomerated into pellets -- an energy-intensive process -- to be suitable for use in the blast furnace. In comparison, the high-grade iron ore deposits available to foreign producers need less grinding and permit agglomeration by sintering (which is less energy-intensive than pelletizing). 13/

U.S. metals producers are at a resource disadvantage also with respect to another aspect of ore quality -- the extent to which ore deposits contain more than one economically recoverable metal. Compared with ore deposits being worked by metals producers abroad, relatively few metal ore deposits in the United States contain commercial quantities of more than one metal, or the quantities are much smaller.

As the previous chapters on specific metals illustrated, the additional revenues yielded by coproduct and byproduct minerals are usually gained with relatively small additions to total costs, and can approach amounts equal to total production costs. Such revenues, therefore, enhance competitiveness by allowing producers to reduce the prices of their primary products, and by permitting greater operational flexibility. Additionally, such revenues ease the adverse effect on profitability of decreases in the market prices of the primary products.

11/ Based on a three-year average for 1960-62 and 1980-82. U.S. Bureau of Mines. "Mining and Quarrying Trends in the Metal and Non-Metal Industries". Minerals Yearbook. 1973-83. Washington, U.S. Government Printing Office.

12/ Page, N.J., and S.C. Creasey. Ore Grade. Metal Production and Energy. U.S. Geological Survey. J. Research, v. 3, No. 1, January-February 1975. pp. 9-13.

13/ See Chapter V in this report for further discussion of the competitive implications of different processing technologies.

Over 90 percent of U.S. lead production comes from mines in which lead is clearly the dominant product, whereas almost all foreign production comes from operations in which zinc, silver and other metals are equal or, quite often, the greater revenue earners. Correspondingly, over three-quarters of U.S. zinc production comes from mines in which lead output is of minor importance, both in terms of zinc producers' revenues and in terms of total U.S. lead production. In contrast, nearly 80 percent of Canada's zinc output comes from copper-zinc or lead-zinc deposits. Mexican and Peruvian zinc ore bodies, too, contain lead, and in addition are heavily enriched with precious metals -- particularly silver.

Energy

Inasmuch as metal mining and primary metal manufacturing (metal smelting and refining) are two of the most energy-intensive industry groups in the economy, energy accounts for a relatively high proportion of total costs in those activities. In metal mining, large amounts of energy are needed to remove and handle the enormous volumes of rock, earth, and ore, and to grind and otherwise process the ore in order to concentrate it. Smelting entails the breaking of chemical bonds through thermal or electrical processes. And in refining, impurities generally are removed through the application of intense heat. 14/ Access to low-cost energy supplies, therefore, affords a metal producer a competitive advantage.

U.S. metal producers once benefitted from relatively abundant, cheap energy and, for a while, from energy price controls. For example, early Federal development of the huge U.S. hydropower potential and regulation of natural gas wellhead prices (beginning in 1954) were instrumental in the rapid growth of the U.S. aluminum industry and in the commercial success of the pelletization of U.S. taconite ore, respectively. Canadian metal producers also have benefitted from ample domestic energy supplies and in some periods from government energy price controls.

Availability of energy, or any input, at lower prices, however, does not necessarily translate into proportionately lower expenditures for energy, because the structure of cost-minimizing incentives will differ from that facing other producers. For example, a lower cost of energy often results in a reduced incentive to minimize energy use. In such cases, the apparent energy cost advantage, therefore, will not be fully realized. On the other hand, capital and labor inputs by "low-energy-cost producers" may be lower as well, since there is less incentive to substitute capital and/or labor for energy.

14/ In 1982, U.S. metal mining and primary metal manufacturing used about 110,000 and 170,000 British Thermal Units (BTUs), respectively, for every 1972 dollar of gross product, compared with 48,000 BTUs for the economy as a whole.

Whatever the ultimate effect, U.S. metal producers' energy cost advantage appears to have decreased. Prices for energy paid by U.S. producers have increased steeply, while low-cost indigenous energy sources abroad have become increasingly available to, and taken advantage of, by foreign producers. Between 1979 and 1984, the average prices paid by U.S. industrial customers for utility electricity and natural gas rose about 120 percent and 65 percent, respectively. Power rates paid by U.S. aluminum producers are now among the highest in the world; 15/ and the cost of electricity to U.S. lead producers may be as much as 30 percent higher than the cost to Canadian and Mexican producers. 16/

Energy developments favorable to foreign metal producers include the following: Brazil and Canada are aggressively developing their hydropower potential; Chile has been using indigenous coal to generate electric power; and Mexico and Peru are making their abundant petroleum and natural gas available for use by local industries.

Use of indigenous energy sources by foreign producers means they have less need to use imported petroleum. The recent decline in world oil prices may only slightly moderate the importance of this factor, because there is a strong incentive to minimize foreign exchange outlays.

It should also be recalled that the type of energy source available determines in some cases -- iron ore agglomeration, for example -- the particular production process used. And, when energy prices among countries change relative to each other, the international competitiveness of a process may well be affected.

Labor Compensation

Labor is the largest single production cost element for most, if not all, U.S. metal mining, smelting, and refining industries. 17/ While effective labor costs are considerably affected by the productivity of labor inputs, the rates of labor compensation play no less a role. The role of productivity is discussed in the next section.

15/ Kennedy, James S. Energy and the Primary Aluminum Industry. International Trade Administration. U.S. Department of Commerce. Washington, U.S. Government Printing Office. 1985. p. 31.

16/ Energy use in the U.S. and foreign lead industries is examined in greater detail in Chapter III.

17/ This holds true for smelting and refining if the cost of raw materials -- a non-factor input -- is excluded.

Data presented in the analyses of the several industries are unambiguous, and confirm the widely held belief that U.S. metal producers pay the highest compensation rates among world metal producers at both the mining and processing levels. In a number of cases, U.S. wages and/or total compensation rates are mutiples of those paid in other countries.

U.S. copper miner's wages, for example, are five times those paid to Chilean or Peruvian copper miners; U.S. lead miners get two to three times the pay of their Latin American counterparts; U.S. zinc miner's wages are two to three times those of zinc miners in developing countries; and the payroll cost per U.S. iron ore miner is roughly twice that for a Venezuelan iron ore miner and four times that for a Brazilian. Essentially, among major competing metal-producing countries, only Canada has labor compensation rates that approach those in the United States. Less information is available for nonwage compensation and for workers in smelters and refineries, but the differentials are believed to be about the same.

The wide differences in labor compensation rates among countries reflect, of course, to some extent wide differences in standards of living, which benefit or penalize producers engaged in world trade. Another major factor is the financial realization by workers of their productivity, or effective contribution to output. This contribution results from the interaction of worker skills and diligence, managerial talents, the quality and quantity of fixed capital, and the quality of ores. Analysis of inter-country differences in the relative extents to which workers realize in pay and benefits such "contributions" is beyond the scope of this study.

Productivity

Partly because metals often occur together in ore deposits in different combinations, and often are produced in different combinations, it is difficult to isolate and quantify productivity levels for individual metal industries and to compare them internationally. But it appears that, historically, higher productivity in the United States (compared with that in most metal mining and processing industries abroad) sufficiently offsets high U.S. labor compensation rates to enable U.S. metal industries to compete effectively at least in U.S. markets. (Higher transportation costs for imported products are also a factor). U.S. production methods, equipment, and managerial techniques tended to be more advanced, and workers more highly skilled.

This characterization is particularly representative of mining operations, and holds true even up to the early 1980s in some instances. For example, output of crude ore per worker in U.S. copper mines in 1983 was 60 percent higher than that in the copper mines of the Corporacion del Cobre de Chile (Codelco). And, although U.S.

zinc miner wages in 1981 were double or triple the levels in competing developing countries, the overall operating cost per ton of zinc ore produced in the United States was 30 percent below that of Mexico and 40 percent below that in Peru.

Increasingly, however, technology and techniques employed in mining and processing move rapidly from one country to another. In addition, because competing foreign metal mining and processing industries generally have been established more recently, they tend to have more advanced capital stock than their counterparts in the United States.

Finally, productivity is greatly affected by the quality of the ore deposits being worked. As described earlier, many years of extraction in the United States has resulted in the "mining-out" of the better grade and more easily extracted ores, while the deposits at newly established foreign mines are closer to their original richness, which in some cases is far higher than was originally characteristic of U.S. ores. Thus, Canadian payroll costs per iron ore miner in 1981 were only 18 percent below that in the United States, but the payroll costs per ton of usable ore were 46 percent lower. Likewise, Brazilian payroll costs per iron miner were about 75 percent below that in the United States, but the payroll costs per ton were 91 percent lower.

It should be noted that this general picture does not hold across all industries. For example, U.S. deposits of lead ore are much more amenable to mechanization than those in Mexico and Peru, providing U.S. producers with at least one cost advantage for the present.

A paucity of data and the greater importance of factors other than labor costs and productivity make it difficult to generalize about the role of labor costs and productivity in the international competitiveness of smelting and refining. In the United States, productivity trends among the copper, lead, zinc, and aluminum smelting and refining industries have been mixed since the late 1970s; some have accelerated, and some have decelerated.

Environmental Regulation

Significant differences between metal producers' pollution control costs in the United States and abroad appear to occur mainly in smelting, where emissions can be very costly to overcome and a serious and expensive legal problem if not abated.

In the industries examined, however, either the approximated difference between the pollution abatement costs of U.S. metal producers and those of foreign competitors account for one-fourth or less of the total difference in production costs, or pollution control costs are not mentioned as a significant factor. The pollution abatement cost differential appears to be most serious for copper (possibly because more data are available). Our research found various cost impact estimates, ranging from 5 cents to 15 cents per pound, but CRS estimates the average additional cost to U.S. producers to be less than 10 cents per pound. This, by itself, our analyst concluded, is not likely to make U.S. producers non-competitive across-the-board. But the additional cost for full compliance (with relevant air quality standards) for older, less efficient, smelters appears to be at least twice that for new capacity. Such additional costs are prohibitive in a competitive sense, and probably will lead to permanent closedown to avoid incurring the high retrofitting costs.

We found that U.S. regulations regarding sulfur dioxide (SO_2) emissions from lead smelters probably did not pose a significant threat to international competitiveness, but regulations on other emissions would have a greater impact. In general, regulations pertaining to zinc smelters are unlikely to be a major competitive disadvantage. Estimates by Charles River Associates of the operating costs of new aluminum smelters in five "countries" put U.S. pollution control costs $23 to $43 per ton higher than in Australia, Brazil, or the Middle East. 18/ These amounts equal 11 to 17 percent of the estimated difference in total "cash" operating costs.

Location and Transportation

Sometimes, the particular location of ore deposits and processing facilities and the relative cost of available transportation significantly affect the competitiveness of delivered materials. Such phenomena appear to have worked to the disadvantage of U.S. metal producers.

For example, because bauxite has a very low value per ton, there is a strong incentive to locate alumina plants and aluminum smelters near mines. This consideration can outweigh production cost advantages held by aluminum smelters in other locations/countries. In the case of iron ore, average charges for seaborne iron ore shipments declined steeply (in constant dollars) between the 1960s and 1980s, while domestic inland water transportation rose. This has lowered the delivered cost of foreign ore relative to U.S. domestic ore.

18/ Charles River Associates Incorporated. Electricity Consumption For Primary Aluminum Production in the Tennessee Valley. Authority Region. CRS Report No. 624 prepared for The Tennessee Valley Authority. October 1981. p. 7.

D. Acquisition and Employment of Capital*

U.S. metals producers have claimed that many foreign producers have access to capital on terms that give foreign producers an advantage. This advantage has been attributed to (a) financing of government-owned operations by public funds that do not require a market rate of return, and (b) Third World countries' access to loans by the multilateral development agencies, whose terms are perceived to be more favorable than those available to U.S. firms through the commercial financial markets. Moreover, it is asserted, sometimes this capital is used in ways not justified by normal economic criteria or constraints.

Forms of Ownership and Financing

The institutional character of some foreign metal firms, such as those in Canada, is essentially identical to those in the United States, in the sense that they are private firms with ownership vested in the publicly traded shares of stock. At the other end of the spectrum, are totally nationalized copper industries, such as the Zambia Consolidated Copper Company (ZCCM). Between these extremes are varying degrees and forms of government involvement. It is important to recognize that those differences may affect the source of capital as well as its cost.

Whereas U.S. producers rely primarily on the capital resources of the private sector, many developing country producers have a broader access to debt financing because they are less restricted by the need to minimize debt-equity ratios. In part, this reflects necessity. Many Third World economies experience a relative scarcity of venture capital, both external and indigenous. This is often accentuated by government restrictions on the share of foreign investment permitted in the mineral industries. At the same time, government loan guarantees -- whether the loans are by foreign sellers of equipment, consumers of the metal, or the host government itself -- reduce the financial risk to the lender of highly leveraged projects in a developing country. 19/

Thus, a developing country producer may often sustain debt-equity ratios as high as 3-to-1. This sharply contrasts with the situation in the United States, where debt-equity ratios of 1-to-4 or

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19/ Mikesell, Raymond. The World Copper Industry: Structure and Economic Analysis. Resources for the Future Series. Baltimore, Johns Hopkins University Press, 1979. pp. 264-65.

*Prepared by John Ellis, Research Assistant, Office of Senior Specialists, and Bernard A. Gelb, Analyst in Industry Economics.

1-to-5 have been the accepted standard, with the appearance of 3-to-5 in the late 1970s being cited as evidence of the copper industry's distressed condition. Restoration of the formerly strong equity position would be viewed in the United States as evidence of the industry's recovery and ability to generate or obtain capital.

On the other hand, in those cases where foreign metal producers rely on funded debt, the interest and retirement schedules of this form of capital provides those firms and governments with less operational flexibility during market downturns.

Opportunity Costs

The opportunity cost of capital in the various countries differs for new outside funds and for the use of retained earnings. Capital cannot always move freely in international markets and the choice among alternative investments is heavily influenced by how a given government treats dividends, capital gains, interest, depreciation, property, and the other aspects of a firm's monetary activities in its tax and other loans and regulations. In the United States, a broad array of potentially profitable investments in a variety of industries competes with prospective copper projects. The government owns no equity in the metals industries and obtains its revenues by taxation. The range of investment alternatives in a developing country may be much more restricted, and the government may participate both as an equity owner and as a taxing agency.

A decision whether or not to retain earnings for capital improvements or to pay them out to the ownership will be quite different depending on whether the recipient is the government or an individual stockholder. The attractiveness of an equity investment in metal mining will depend upon what investment alternatives a firm has at its disposal. What really determines whether a debt-equity ratio is tolerable is what stands behind the debt -- the guarantee of a government or merely the firm's own assets.

The variation among nations in opportunity costs may result in a "comparative advantage" for one nation over another. Thus, Peru could have a "comparative advantage" over the United States in copper, because copper investments offer a superior opportunity compared to other investments in an economy from which capital cannot easily emigrate. U.S. firms may choose between economic activities, both at home and abroad, which currently offer a better return.
Nonetheless, comparative advantages do not necessarily reflect relative competitiveness within a given industry. Peru might continue to invest in future copper production in this example, even if its costs were higher than in the United States.

It can be observed that both the United States and foreign nations rely less upon retained earnings for expansion and improvements, but for different reasons. In the United States, internal cash flows have diminished and the private opportunity cost is high because of the availability of many profitable alternative investments. In low-cost developing nations, the cash flow may be there and reinvestment attractive, but the government may choose to allocate retained earnings from metal operations to their central banks for other national purposes, because they deem the public opportunity costs of using those funds for reinvestment in metal production to be too high.

Foreign Producers' Costs of Debt Financing

The International Monetary Fund (IMF) is an important source of loan capital to the developing countries. During the economic recession of the early 1980s, it accounted for over 60 percent of the multilateral assistance going to members of CIPEC (the association of copper exporters, including Chile, Peru, Zaire, and Zambia) between 1982 and the first quarter of 1984. [20]

IMF loans, however, are only provided to governments for balance-of-payments purposes, and cannot be allocated for specific commercial ventures. But because the IMF is prohibited by charter from dictating the recipient country's industrial or microeconomic policies, there is nothing in principle to prevent a recipient government from investing some of that foreign exchange in its minerals sector.

The IMF has imposed increasingly stringent "conditionality" requirements on countries whose severe debt problems have necessitated applying for assistance under the IMF's higher "credit tranches". [21] In the cases of some developing countries that are inordinately dependent on copper export revenues (e.g., Zambia), the IMF has used its "conditionality" powers to require diversification into other industries. [22] On the other hand, the IMF has, in some cases, urged greater investment in profitable copper operations that have been denied adequate investment funds by their cash-starved government owners (e.g., Chile and Zaire).

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[20] Everest Consulting Associates, Inc. IMF and Development Bank Lending to CIPEC Majors, Data for Analysis. April 2, 1984. p. 13.

[21] Members of the IMF may draw funds free of charge up to the level of their quota contribution. Those drawings are said to occur under the "Reserve Tranche". Drawings above the level of a country's quota take place under four "Credit Tranches" and are subject to an interest charge and progressively more stringent "conditionality" restrictions on their economic policies.

[22] Zambia Gets IMF Loan for Economic Reform. Journal of Commerce. April 26, 1983. p. 6A.

It is generally accepted that financing terms under the IMF are as stringent as the terms offered by private commercial banks. Interest rates on IMF credit drawings include a 6.6 percent charge (7.0 percent after April 1, 1984) on holdings in excess of members' quotas and a basic annual lending rate that follows the market and that varied, in March 1984, between 8.75 percent and 9 percent. Under the normal credit tranches and under the Compensatory Financing Facility, those loans must be repaid in three to five years. 23/

The multilateral development banks (MDBs), including the World Bank, the Inter-American Development Bank, (IADB), and the African Development Bank, do provide direct assistance for individual development projects. These organizations, which command fewer financial resources than the IMF, maintain lists of individual countries that, because of exceptional need, are eligible for concessionary assistance. MDB officials maintain, however, that their non-conecessionary loan terms (such as those applying to a recent $268 million loan by the IADB to Chile), are generally in line with commercial rates. In any event, it is frequently noted that MDB loans are transferred to the recipient country's central bank, which normally re-lends the funds to the ultimate users at terms currently prevailing in the market. The benefits derived from any MDB's preferential loan terms, then, tend to accrue to the recipient government rather than to the project operator itself.

Employment of Capital

As suggested in the section on opportunity costs, metal producers in other countries, particularly when government-owned, are faced with different circumstances and criteria for investment decisions than are U.S. producers. Foreign producers often must defer to the nation's need or desire to use foreign exchange earnings from the sale of metal to meet national goals, the political need to sustain employment, the high cost and limited availability of equity capital, and the ability to function under higher debt-equity ratios. High fixed-payment schedules (for interest and debt retirement) often result in reluctance to reduce output when market demand weakens and prices soften, even when this reluctance means a lower return on investment. 24/

23/ Everest Consulting. IMF and Development Bank Lending. p. 4.

24/ For example, world copper mine output rose 6 percent between 1980 and 1984, although the price of refined copper fell about 35 percent. (U.S. Bureau of Mines, Minerals Yearbook). Chile accounted for 40 percent of the increase in world output, although that country's production represented only 14 percent of 1980 world output (Minerals Yearbook); and about two-thirds of the Chilean increase was

On balance, and disregarding the broader issue of the relative wisdom of national economic strategy, the circumstances faced by many foreign producers can lead to a lower effective cost of capital in the long-term, and to less fluctuating levels of output in the short-term for the foreign producer of copper, compared with its counterparts in the United States.

E. Subsidies and Burdens*

In discussions of competitive difficulties experienced by U.S. metal producers, it has been asserted many times by industry leaders, their representatives in Congress, and others, that at least some foreign producers are subsidized by their governments. 25/ There is an unstated implication that U.S. metals producers are not subsidized. Appraisal of the competitive significance of subsidies that benefit foreign producers, however, must take into account any subsidies enjoyed by U.S. producers, and any additional government-induced costs borne by foreign or U.S. producers.

Limitations of time and resources prevented the authors of this report from ascertaining and thoroughly quantifying the way in which foreign and U.S. producers benefit from subsidies or are subject to governmental burdens. This section, therefore, only enumerates those subsidies and burdens believed to be common and of significant impact abroad and domestically, and compares the sums of the benefits and costs only in a general fashion.

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accounted for by the Chilean state-owned copper corporation Codelco (Corporation National del Cobre de Chile). (Codelco Annual Reports). According to the Financial Times (April 10, 1985, p. 20), almost half of Chile's foreign exchange earnings came from Codelco's exports and nearly all of the $600 million per year that Codelco pays, on average, in dividends, income taxes, and other levies to the Chilean treasury is used toward payment of interest on the government's foreign debt. Codelco asserts that increases in its output are justified, because it is a low-cost producer.

25/ See, for example, the following: MacAvoy, Paul W., "A Policy that closes U.S. Copper Mines", The New York Times, December 19, 1982. p. F3; Reuters. "Copper Quotas Sought", The New York Times, January 27, 1984. p. D4. (Contains reported statement by Richard Osborne, President Asarco, Inc.); DeConcini, Dennis. Remarks in the Senate. Congressional Record, Daily Edition, v. 130, May 22, 1984. p. S6252; Serrin, William, "Helping Phelps Dodge Fight Big Odds at Home and Abroad", The New York Times, September 23, 1984. p. 6F. (Contains reported statement by George B. Munroe, Chairman, Phelps Dodge Corporation).

*Prepared by Bernard A. Gelb, Analyst in Industry Economics.

What Is a Subsidy?

Roughly speaking, a subsidy is the government provision of direct or indirect economic assistance to one or more economic units in the in the private sector or government-owned, aimed at encouraging a particular type of economic activity. Such aid usually can be classified as falling in one or more of five main categories: direct payments (in cash or in kind); provision of goods or services below full cost; tax forgiveness; risk absorption; and promotional devices. There can be considerable disagreement, however, as to what constitutes a subsidy, and there are many instances of unintentional economic assistance that differ from purposeful subsidies only in intent. 26/

Some Specific Subsidies -- Actual and Alleged

Energy. Because metal mining and processing are very energy-intensive, the cost of energy has been a prime area for governments to assist their local metals industries. Energy subsidies -- the provision of energy at rates that are below full cost -- appear to be the best documented of all asserted subsidies to metals industries.

The International Trade Administration (ITA) of the U.S. Department of Commerce reports that concessionary rates or subsidies for electric power for existing aluminum smelters are provided by the governments of Norway, Sweden, and Turkey, and that Brazil and Canada offer sharply discounted power rates in order to attract new smelters. 27/ Such subsidization is simple when power generation is government-owned and operated.

Aluminum smelters in the United States are not nearly as favored. They once benefitted from "low-cost, essentially subsidized power, as typified by the historic pricing policies of the Bonneville Power Administration (BPA) and Tennessee Valley Authority..." according to

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26/ The set of categories used here is partly based on those used in Wilcox, Clair, and William G. Shepherd. Public Policies Toward Business. Homewood, Ill., Richard D. Irwin, 1975. p. 633. A detailed discussion of the definition and forms of subsidies can be found in U.S. Congress. Joint Economic Committee. The Economics of Federal Subsidy Programs. Joint Committee Print, 92nd Congress, 1st Session. Washington, U.S. Government Printing Office. 1972. pp. 7-21.

27/ Kennedy, Energy and the Primary Aluminum Industry. p. 32.

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the U.S. Bureau of Mines. 28/ But, in the past decade, those authorities have increased steeply their rates to aluminum smelters, as their generation costs have risen (largely due to lack of new hydropower sources and to high costs of nuclear construction), and their rates generally reflect present-day generation costs. In mid-1985, however, BPA began to slightly subsidize rates to aluminum smelters (at the expense of residential and agricultural electricity users) to try to prevent the emigration (possibly abroad) by aluminum producers.

ITA reports the Organization for Economic Cooperation and Development (OECD) to have stated that "...the information available on power prices to smelters...clearly shows that policy differences explain a large part of the variations observed in power prices paid by smelters throughout the world". 29/ In another context, PEMEX, the Mexican national oil company, makes low-priced energy generally available to Mexican industries. Thus, it may well be providing heavy fuel oil to its indigenous lead mining and processing industry at less than the price charged to foreign customers. (See the section on the lead industry).

Transportation. It also has been asserted that government ownership and operation of transportation networks, common in other countries, facilitates the provision of below-cost transportation services to metals producers abroad. Because ores and concentrates are bulky and relatively low-value products, transportation potentially can account for a relatively large proportion of the total cost of mining, milling, smelting, and refining of a metal. Our research did not come upon any examples of transportation subsidies.

Investment Capital. Alleged access to investment capital at lower than market rates for some metals industries abroad, discussed in the section on the acquisition and employment of capital, deserves to be mentioned again in the present general discussion of subsidies. It was found that some producers abroad, directly or indirectly, obtain capital that they would not be able to get at the same cost in private capital markets, and that government backing of some type in some cases permits commercial operations at higher debt-equity ratios than would otherwise be possible. But, it was also found that foreign entities often are constrained by national economic or political policies.

28/ Peterson, Gary R., and S.V. Arbelbide. Aluminum Availability -- Market Economy Countries. Bureau of Mines, U.S. Department of the Interior. Information Circular 8917. Washington, 1983. p. 17.

29/ Ibid., p. 32. ITA does not cite the specific OCED report containing the quoted statement.

Overall, however, government-induced changes in the framework of investment and production decisions for many foreign producers, and the relative costs of those decisions, generally appear to have affected U.S. producers adversely.

Environmental Protection. Less restrictive environmental regulations abroad than in the United States, also discussed previously, can be considered a type of subsidy relative to what U.S. metals producers must bear. This is because societies abroad bear relatively more of the social costs resulting from environmental degradation compared with the United States. Industries abroad, for example, have the use of air or water at further below full (social) cost than in the United States. In the industries examined, however, either the approximated difference between pollution costs in the United States and those abroad account for one-fourth or less of the total difference in cost of production, or pollution costs are not mentioned as a significant factor.

Taxes. Because tax structures differ among nations, and because metal producing operations in some countries are government-owned, it is difficult to ascertain and compare net tax burdens on industries in different countries. For example, while corporate income tax rates are higher in Chile and Peru than in the United States, those countries have special provisions for accelerated depreciation of capital. 30/ On the other hand, U.S. producers benefit from relatively high percentage depletion allowances, rather than cost depletion allowances as well as from the expensing of exploration and development costs. 31/ Somewhat similarly, the federal and provincial governments in Canada may subject Canadian producers to a higher combined base tax level than that borne by U.S. producers; but, at the same time, those governments also provide an assortment of exploration and development deductions, investment credits, and depletion allowances. These reduce the net tax burdens on copper producers, for example, to the U.S. level or below.

30/ In the United States, capital recovery for tax purposes was accelerated by the Economic Recovery Tax Act of 1981 (P.L. 97-34), and then decelerated by the Tax Equity and Fiscal Responsibility Act of 1982 (P.L. 97-248).

31/ Under percentage depletion, a firm is permitted to charge as an expense a legislatively specified proportion of gross income, rather than the proportion of the original cost of the firm's mineral reserve measured by the proportion of the mineral extracted each year. The percentages are often substantially higher than the proportions of the reserves extracted in a given period. For example, the rates for lead, molybdenum, and zinc are 22 percent; those for copper and iron ore are 15 percent.

Special levies also can come into play. For example, both private and government-owned producers in Chile are subject to a 10 percent tax on export sales of copper. Codelco's payments of this tax equalled 24 percent of before-tax earnings, on average, from 1979 through 1983. Payments of mine taxes averaged 35 percent of before-tax earnings. 32/

In general, it does not appear that foreign metal producers enjoy lower rates of taxation than their U.S. counterparts. Data from the U.S. Bureau of Mines' Minerals Availability Survey (shown in the individual industry analyses) in fact indicate that, at least for copper, lead and zinc, U.S. producers tend to be subject to a smaller tax burden (in absolute terms) than their foreign competitors.

Burdens and Risks

Whereas domestic metal producers usually have a well-developed social and industrial infrastructure available and benefit from a stable legal system, producers abroad -- particularly those in less developed countries -- often do not. Shortcomings in one or more of these elements generally result -- in one way or another -- in higher costs for producers or in the discouraging of investments.

Infrastructure. A functioning metal producing operation requires access to basic services such as transportation, electric power, and water. When adequate railways, roads, electric power grids, or water distribution systems are not available, as is often the case in Third World countries, the industrial enterprise -- private or government-owned -- usually must, directly or indirectly, provide them or pay for their construction. Similarly, in developing countries where mining operations are dependent upon the government to maintain certain parts of infrastructure, inadequate maintenance of roads, electric power grids or water distribution systems will hinder metal operations and raise costs. Industrial ventures are also often required to provide "social infrastructure", such as schools, hospitals, and housing. Data developed for the copper industry indicate that the need to build or provide various items of infrastructure can raise initial investment costs by 50 to 100 percent for "greenfield" projects. 33/

32/ Corporacion Nacional del Cobre de Chile. Annual Reports, 1980, 1982, 1983.

33/ Bottge, R.G. Comparative Porphyry Copper Mining and Processing Costs-Alaska and Arizona. Washington, U.S. Bureau of Mines, 1974. Information Circular 8656; U.S. Department of the Interior. Bureau of Mines. Minerals Availability Program. Unpublished data.

Expansion or retrofit projects, however, are not likely to entail as much need, per unit of capacity, for additional infrastructure as in the case of greenfield projects, and, relatively speaking, investment costs will not be affected as much. This factor, therefore, tends to deter investment in new mineral projects in less developed countries. And the potential advantage U.S. producers might derive from the availability of infrastructure is diminished to the extent that producers abroad build on operations already in place.

Capital goods availability. As discussed in the analysis of copper (Chapter II), metal producers in less developed nations often suffer also from the disadvantage of having limited indigenous capital goods sectors in their countries. This circumstance forces those producers to import the bulk of their capital equipment from the United States and other industrialized economies. Such importation, because of higher transportation charges usually must be paid, for example, tends to raise the cost of capital equipment above that incurred by competing producers in industrialized countries.

Political and legal uncertainties. Private ownership of industrial enterprises in some countries faces a much higher level of political and legal uncertainty than in the United States, or such ownership is at least perceived to entail greater uncertainty. Existing or prospective metal operations in less politically and/or legally stable nations see a greater threat of nationalization or expropriation, loss of title, altered tax laws, or voided contracts. The last quarter of a century includes nationalization of mineral industries by Chile, Ghana, Tanzania, and Zambia, among others; seizure of mines by insurgents in Zaire; poor documentation of land titles in Bolivia; and forced renegotiation of a development and production contract in Papua New Guinea. 34/

U.S. producers, also, are subject to politically originated changes in the rules. Changes in administration in the United States every four or eight years can result in changes in minerals policy -- such as availability of public lands for mineral development. 35/

It is difficult to translate the actual and perceived uncertainty, if not actual ultimate negative results, into units of cost. This is particularly so because if perceived threats are great enough, investment in metals production will not occur. At least regarding this cost consideration, U.S. producers have the edge.

34/ Groten, Eric, and W.C.V. van Rensburg. Barriers to Investment in Third World Mineral Industries. Resources Policy, v. 9, March 1983. pp. 35-39.

35/ Ibid., p. 37.

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Overview of the Significance of Subsidies

The preceding brief review reveals examples of the provision of economic assistance to metals producers abroad by foreign governments -- particularly with respect to the cost and availability of energy and capital, and laws to protect the environment. Energy cost advantages appear to be most common and important for aluminum production, and easier environmental regulations most significant for copper smelting. The potential for a foreign metal producer obtaining investment capital advantages exists mainly in those countries where government-owned operations are common and for the particular industries that those countries' natural resource endowments permit. Examples are aluminum in Venezuela, copper and molybdenum in Chile, iron ore in Brazil, and zinc in Peru.

There is also contrasting evidence that, at least in the cases of copper, lead, and zinc, U.S. producers pay lower direct taxes, on average, than their foreign counterparts. Moreover, many foreign producers must incur heavier initial investment outlays as a result of their location in countries with inadequate physical or social infrastructure, or inadequate capital goods sectors. In addition, unstable political and legal climates in some foreign countries add directly or indirectly to foreign metal producers' costs.

Because measurement is troublesome and the importance of these countervailing factors varies by country and by metals industry, it is difficult to judge with any precision how significant subsidies (or burdens) are in determining the competitiveness of U.S. metals industries individually or as a group. It appears from the specific examples and general tendencies that foreign producers enjoy a net benefit more often than do U.S. producers. It is clear, however, that there is not overwhelming evidence that foreign producers enjoy a substantial net subsidy advantage across all metal industries.

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XI. THE ISSUES AND THE UNCERTAINTIES IN THE FUTURE OF U.S. METAL MINING*

A. The Importance of the Metal Mining Sector

For much of our early history, the nation's primary attention was directed toward providing the simple necessities of life -- food, shelter, and clothing. In any agrarian or emerging economy when these needs are met, then resources and effort can be directed toward economic growth and the production of other goods and services. In this historical sequence, the mineral sector never seems to attract the same degree of broad-gauged public attention as does agriculture. Despite the frequent efforts to publicize the basic importance of mineral resources to an industrial society, the mineral industries tend to remain "just another part of industry". Public concern about the mineral industries tends to be localized rather than general. There are temporary periods of national awareness about wartime materials shortages or energy interruptions resulting from political upheavals in the Middle East. But these have not spurred Congress to establish a whole spectrum of policies and rules to protect and nurture the mineral industries in particular. This is notwithstanding the presence of some targeted attention to minerals such as the percentage depletion allowance or some facets of public land policy.

Metals, nonetheless, are essential materials and are important to our industrial economy. It is useful to be conscious of the relative size of the metals and metals processing sectors as viewed in the context of the total economy. The extractive industries, fuels, metals, and nonmetallics have provided a fairly consistent proportion of the nation's national product over the past 60 years. In the short-term, this may vary because of the acceleration principle at work during business cycles. In 1983, the value of U.S. fuel and non-fuel mineral production was $172 billion, or 5.2 percent of the Gross National Product (GNP). This is close to the average since 1920 when it was estimated to have been five percent, with a range of three to nine percent in given years.

If we separate the value of primary metals production from the other extractive resources production, the picture is somewhat different over time. The value of domestic metals input has shrunk relative to the economy and to the other extractive resources. While conservation in recent years has reduced the energy-intensity of U.S. society, the higher unit cost of energy has meant that the mineral fuels have remained the dominant member of the mineral industries. Nonmetallics in more recent years have moved ahead of the metals group in terms of gross value of output. As a consequence, the primary metals, which typically contributed 0.5 percent to GNP from 1930 to 1980 provided only 0.2 percent of GNP in 1983. 1/

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*Prepared by John J. Schanz, Jr., Senior Specialist, Energy and Natural Resources, and Karen L. Hendrixson, Research Assistant, Office of Senior Specialists.

Congress has always expressed its general concern about essential industries and about their contribution to the economy. A primary example is the Mineral Policy Act of 1970. Even more important to Congress is the adverse impact of economic change on local communities. Thus, the decline in the mining sector's contributory share to GNP and in the decline of the mining workforce by one-third has attracted Congressional atention. From a high of 167,200 in 1974, the metal mining and smelting workforce by 1984 declined by over one-third to 107,400, equal to a halving of mining's proportion of the total U.S. non-agricultural workforce. 2/

But there are two other important dimensions to the plight of the metals mining industry when it is examined by the Congress. One, despite the acknowledged fundamental importance of metals, the industry's operators are confined to a limited number of locales and its most visible economic impact is likewise localized. Two, when remedial measures are considered toward responding to the problems of the metal industries and its employees, the broader impact of such actions on the workforce in the other sectors of the economy and the nation also receives critical attention. These two dimensions are not always compiimentary, and the political resolution that emerges may not always be the one sought by the mining industry.

B. The Current Challenge to the Metals Industry

The domestic metals industry has now been buffeted for five years by a chain of untoward developments. First a recession followed the more prosperous 1970s. Then there was a dawning realization that unlike the past, boom was not following bust and the mining sector

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1/ Value of mineral production relative to GNP. Calculation by CRS based on data from U.S. Department of Commerce, Bureau of Economic Analysis, and U.S. Bureau of Mines.

2/ Annual average, including all employees. 1974 represents a post-1958 employment high for primary nonferrous metals workers (SIC 333) and one of the years of highest employment for mining employees (SIC 10) in that same period. Employment and Earnings data. U.S. Department of Labor, Bureau of Labor Statistics.

was not participating in the economic recovery. Moreover, for the variety of reasons we have identified, other producer nations were penetrating the domestic marketplace and taking away markets and jobs. Not only was there no boom, there was further decline. What responses are there to these various circumstances that face the firms that mine metals?

The quality of the ore deposits that remain to be mined within the borders of the United States is a fixed condition that cannot be changed and we must do the best with what we have. There is always the hope that competitive low-cost world "class" deposits are still remaining to be discovered somewhere in the West, or in Alaska or hidden below the surface. But it is unlikely that anyone for some time will be eager to supply the dollars to unravel this uncertainty by mounting a major exploration effort. Paradoxically, should this occur, the United States as a result might well be contributing to the very condition it protests abroad, the development of new capacity when not warranted by world supply and demand.

Since the U.S. net advantage in energy production has declined, the cost of a unit of energy in the United States is now externally determined to a considerable degree. The current fragility of OPEC's management of the world oil price offers the prospect of some short-term relief. But at some point in the not too distant future, OPEC, or Saudi Arabia alone, could reassert itself. This suggests that the American metals industry must turn toward cost-cutting through means other than relying upon the natural attributes of its own resource inputs.

One might view recent limited response by the domestic mining industry to the improvement in the general economy as merely an aberration. If so, the customary boom and bust cycle might reappear in the future and expanded metals demand would pull the industry out of its doldrums. This possibility is countered by those who expect that the structure of the U.S. economy is undergoing a fundamental change that entails a change in reliance on primary metals. Even within the same economic structure there is emerging evidence that the American populace and a mature U.S. industry may be becoming less intensive in their demand for materials. There are smaller and lighter manufactures and substitution occurring from new and old non-metallic materials. There is also the less obvious erosion of domestic metals demand in the form of foreign metals imbedded in imported manufactures. In the past, both U.S. and foreign manufacturers were more dependent upon U.S. mines and smelters.

There is emerging evidence that mining does have internal opportunities to improve its future. The recent chain of events at Phelps Dodge, as reported by Forbes Magazine, is illustrative. 3/ In 1983,

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3/ Cook, J. Hanging on. Forbes. December 30, 1985. pp. 36, 42.

the company lost $63.5 million when the price of copper was $0.77 per pound. It appeared likely that losses were going to reach $100 million per year. But currently Phelps Dodge has pushed its breakeven point back down toward $0.60 per pound while the price of copper has moved to around $0.70 per pound. This has been achieved by the aggressive lowering of labor costs following a difficult confrontation between the union and the company; the selling off of all or part of some segments of the company; the writing-off of losses; the turning to equity for additional funds rather than funded debt; the shutting down of high-cost copper and uranium mines; and the closing of two smelters and operating only two. The company also sold a 15 percent stake in its Morenci mine to a Japanese firm, thereby not only realizing extra funds, but also securing an additional outlet for its output. Phelps Dodge in 1985 became the first copper company to return to operating in the black, with $62 million in earnings for the year compared to $101.9 million in losses in 1984. 4/ But not all was retrenchment. Money was also invested in a new $0.30 per pound solvent extraction process and the remaining efficient mines and smelters were operated at full capacity to keep their unit costs low. With the cash that has now become available to it, Phelps Dodge is turning toward debt reduction and opportunities for diversification, yet is doing so without turning its back on copper as a major part of its business.

Phelps Dodge's recent experience is not an isolated case. Other companies are also being forced to adopt new strategies to adjust to the realities of highly competitive metal markets that are likely to be characterized by slow growth rates in demand because of the structural change in demand in the United States and worldwide. ASARCO has cut its labor force by 21 percent, reached agreement with its union to freeze wages, and pruned its weakest operations. Standard Oil Company of Ohio (Sohio) announced in December 1985 that it would suspend operations while spending $400 million over three years to modernize its Utah Copper Division's facilities, which includes the famous Bingham Canyon mine. This was made in recognition of the fact that when Sohio acquired Kennecott the copper operation was no longer competitive due to labor costs and the antiquated mining, transport, and processing facilities. It is expected that operations at the end of the modernization period will compare favorably with those in the rest of the world.

Similar activities can be found in other metals. In an unprecedented move that other companies are seeking to emulate, Kaiser Aluminum Company has renegotiated its labor contract with its workers to cut wage costs by over $50 million. 5/ U.S. aluminum firms are

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4/ American Metal Market. Phelps Dodge Reports Net Earnings for 1985. February 5, 1986. p. 2.

5/ American Metal Market. Aluminum Companies Target Labor, Power to Cut Costs. May 24, 1985. p. 5.

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also trying to renegotiate lower power rates to reduce the burden of energy costs, and are expecting that energy conservation measures could halve energy requirements by the end of the century. One major contribution to the industry's reduced energy need is the steady increase in its reliance on secondary aluminum. For example, aluminum cans are now approaching 100 percent content of recycled metal.

Segments of the mining industry have also turned, as might be expected, to the Federal Government for aid and protection. In the past two years, proposed forms of assistance have included direct subsidy in various forms, tariffs, quotas, stockpile purchases, and new international institutions to control monthly capacity and output. The creation of a variety of other less direct mechanisms are being suggested. Each remedy is likely to involve problems of implementation, uncertainties as to effectiveness, or higher costs for U.S. consumers. Merely increasing the delivered cost of a metal of foreign origin by perhaps $0.10 or $0.15 per pound will not solve the basic problem of a any given domestic mine that has a break-even point twenty cents above the current market price. The consequent reduction in demand from increased prices must also be anticipated. Many plans are only short-term solutions at best. Stockpile purchases from domestic sources can only ease the problem until the purchase goals are met. Most quota systems may also be viewed as temporary measures, raising the question of whether the industry will be any less vulnerable when the protection is lifted.

The critical element in the decision to protect or not to protect the domestic metal mining industry is found in opposition based on a combination of economic, political, and ideological grounds. Manufacturing firms that are materials-intensive are quick to oppose protection because it increases their costs and affects their own competitiveness against foreign producers. This was quite apparent when protection for the copper industry was being considered by the Executive Office of the President in the summer of 1984. The comparative size of these downstream consumers when compared to the mining sector are likely to be an important factor in determining the willingness of the Federal Government to pursue a protectionist stance.

Domestic mining in recent years has become far more vulnerable to cyclical market behavior, inflation, and volatile interest rates than was true in its past. Christian F. Baiz, III, group head of the Metals and Mining Group of Manufacturers Hanover Trust Company, has explained the financial evolution of the mining industry over the years. 6/

6/ Baiz, C.F. Capital Formation and Project Finance Prospects: A New Agenda for Metals Mining. Mining Engineering. August 1985. pp. 1044-1046.

A new mining agenda is before us. Born of government policies and world economies, the years ahead will show reduced growth. Metals, mining, and most other natural resource industries are inflation dependent and capital intensive. For these, a long period of contraction of outmoded and costly capacity will evolve. In some cases, this will be supplanted by new, lower cost capacity. But this will occur only if the cost of production -- including cash operating and debt service costs -- comes in at or below current market conditions.

One must look back 30 years to see the evolution of the capital markets, for metal mine financing. This period can be divided into two economic periods. The 1950s were a time of stable economics. Mining companies earned and reported good profits. They had good corporate creditworthiness. In essence, mining companies of the 1950s were highly self-reliant. When equity infusions were needed, they were easily obtained. Financial management kept long-term debt low.

Fixed rate, long-term financing was readily available in the long-term bond markets. The commercial banks of the 1950s were rarely used by the mining industry. When necessary, mining companies went to the banks for short-term financing -- the kind that was needed for working capital requirements.

Beginning in the late 1950s, for the first time in mine financing, the risk of success shifted from the corporate balance sheet to third parties. Limited-resource financings were taken up by banking syndicates that accepted certain of these risks. The lender needed to be well acquainted with the types of risks to be evaluated. These include resource quality and quantity, construction and completion, capital and operations costs, market risks, force majeure, and political and exchange rate risks.

Capital formation for the mining industry will continue in this new environment. Currently, many metal mining companies are in difficult financial conditions.

Return on equity as an industry average has fallen from 20% in the mid-1970s to less than 0.5% in 1983. Debt as a percentage of capital has risen well above 50%.

Credit ratings of all those firms have slipped, say from B to B-. Therefore, the ability to raise money has become more difficult. Lower stock prices also make equity issues unrewarding.

Thus, if project financing is to go forward for this industry, how can one find financing deals? The first step is to find ways of lowering the capital costs of projects. This means smaller projects and better costengineered projects, such as leaching operations. Where bigger was better for some time, smaller is now better.

The result is that the metal mining industry is more vulnerable than in the past. For the future, volatile interest rates become the greatest uncertainty. Moreover, increased competition through technology along with buyer sophistication in borrowing funds have tightened the grip on that uncertainty.

C. The External Forces At Work

This far ranging examination of U.S. mining has served to demonstrate that no one factor can or should be singled out as being the prime cause behind what is now being experienced by the domestic mining sector. But perhaps more important to recognize is that among the cluster of factors that are influential there are a number which the metals industry has little or no influence now or in the future.

The strength of the dollar is believed by many to be the root problem. As it now weakens, we can judge how important it really is. There is no doubt that foreign exchange rates have been truly significant in their impact on the mining industry. But the political and economic forces that move both U.S. monetary and fiscal policy and international financial institutions are not responding to the problems of this one small sector. U.S. mining companies will continue to endure whatever fate befalls them in this respect. To date, the intractability of the U.S. deficit problem does not suggest that the adverse impact of exchange rates on the mining industry is necessarily ended permanently.

It is undoubtedly true that the behavior of the various metal producing developing countries is affected by the funds they receive from commercial banks or from various government-supporting sources. How, and when, these funds are provided as well as the terms of repayment now directly or indirectly affects what mines and smelters are now opened in the world and how they are operated. While it is possible to pursue some controls and restraints on the U.S. involvement in such international financial affairs, again we are facing economic issues that are so much broader than mining that it is unlikely that the outcomes can be signficantly influenced solely as a consequence of concerns about the American mining sector. This is particularly so because some other segments of the U.S. economy may indirectly benefit from these loans. These sectors range from exporters of U.S.-made mining equipment to farmers whose output is purchased with the foreign exchange earned by developing nations' metal exports. This does not suggest, however, that it is necessarily impossible to achieve some alteration of lending practices on the part of these institutions so to avoid continued disturbances of metal markets through lending encouraging the development of more major mining projects in developing areas.

Finally, the world is not likely to return to markets where a few countries and less than a dozen private firms are the dominant actors. While metal commodities have always behaved cyclically, those rhythms were expected and the markets could be viewed in that context as being relatively orderly. It was tacitly accepted that most producers, except those aggressively seeking to expand market shares, would cut back on production as prices fell, and the losses would be felt mainly as reduced earnings. When economic growth resumed, new capital would be sought and used to meet the coming surge in demand. Third World producers today, however, do not appear to respond in a like manner to the ebb and flow of commodity economics, but rather to the need for more income as a political necessity.

No matter how much U.S. mining firms may decry this behavior, the market patterns of twenty years ago are not likely to return. International negotiations and forums may help to ease some of the difficulties, but we are not likely to find governments behaving in their marketing strategies as though they were private firms. Those mines that now find themselves somewhere between the industry's average cost and the upper margin of cost are not likely to find world markets to be an accommodating environment. At the same time, any attempt by the United States to employ countervailing duties in response to alleged subsidies by foreign metal producers, given the terms of the General Agreement on Tariffs and Trade (GATT), the needs of consumers, and current U.S. trade policy, would have to be crafted very carefully to be acceptable at home and abroad.

D. The National Security Issue

Public Law 91-631, the Mining and Minerals Policy Act of 1970, is quite explicit. It states that "...it is the continuing policy of the Federal Government in the national interest to foster and encourage private enterprise in...the orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of...security... needs...".

Prior to World War II, most resource analysts defined critical and strategic minerals as those needed by basic industry. These included coal, steel, copper, lead, zinc, and the like. In more recent years, strategic minerals have largely been defined as selected critical materials for which we were dependent upon vulnerable, distant sources, such as chromium, cobalt, or manganese. The base metals were produced at home, while the exotic and high-tech materials were our potential Achilles heel in wartime.

The question now arises whether the nation's basic security is endangered if it is no longer self-reliant in metals to supply its industrial capacity. This has not been a concern since the United

States became a major industrial power. What happens if we cannot produce some specified minimum level of copper at home to sustain our industrial complex, if deprived of the usual and growing flow of internationally traded commodities? Having low or no reserves of a small group of high value, low volume commodities such as cobalt is far different than the loss of half or more of our capacity to produce the family of common non-ferrous metals. A combination of stockpiling, conservation, and substitution which is deemed to be sufficient for the critical minerals may not be adequate here. In addition, the cost, magnitude, and logistics of using such measures to compensate for the loss of this component of our industrial complex is markedly different.

This broad question is bound to be raised and will have to be addressed. But the analysis, as well as the possible answers, are not ones we have had to deal with before in any real depth or with much sophistication. The problem is compounded by the fact that while this question can be raised for each major mineral commodity, the answer is likely to be different, to some degree for each. One can imagine a finding, for example, that a natonal effort should be made toward retaining active capacity levels at some specified percentage of U.S. copper consumption. It is not likely that a similar percentage would be equally valid for lead and zinc.

E. Other Areas Needing Investigation in Depth

While not a welcome assumption to the affected workers and industries, one valid possibility for the future is that the United States will continue to find its reliance on domestically produced and processed metal resources slowly diminishing. We might become increasingly more an importer of raw and unfinished goods and an exporter of sophisticated manufactures and other internationally marketable items. This would place a premium on the United States assuring itself of diverse, low cost sources of mineral raw materials on a global scale. Diversification would be critical under these circumstances because it works toward assuring reliability of supply and the resulting competition would be contributory to the achievement of the lowest possible cost supply stream.

If the United States would become more of a trader than in the past, when we traded our surpluses and filled in a few mineral deficiencies, then our modus operandi would need to be subjected to greater scrutiny than in the past. One issue of concern would be whether the development of the world's mineral potential will be timely and occur in a fashion that is supportive of U.S. interests by enabling ready access. We would need to move from a somewhat passive role to one that is more aggressive. This suggests greater involvement in foreign exploration. This would constitute an early involvement in newly emerging supply sources so as to gain access to those supplies to meet future needs. Our geopolitical strategy could well begin to more resemble that of Western Europe and Japan than in the past. At the same time, we would be recognizing that alternatives to reliance on sub-Saharan Africa in international resource affairs might be pursued.

In this same vein, without moving sharply away from our national predilection for free trade and the separation of government from the affairs of private enterprise, the past relationships between the Federal Government and those firms engaged either in the exportation or the importation of goods and materials might benefit from periodic reappraisal. Without necessarily having government and industry becoming partners in fact, one would surmise that mutual support, and some commonality of goals and strategies for achieving those goals could be considered more frequently than has been the case in the past century. It may well be that a federal presence in matters relating to mineral-based commerce becomes a more regular event than only occurring when active political or military confrontation is involved.

Finally, charges and counter-charges between the United States and its trading partners concerning unfair subsidies are likely to continue unabated. These are frequently rhetorical and often not supported by substance and specific detail. The definition, detection, and quantification of what are truly subsidies and how important they may be in the outcome of competition in minerals trade is still not well understood, nor has it been the target of well developed, applied research. It may now be an opportune time to begin to correct this deficiency through some pragmatic surveillance by government, industry, and individual researchers.

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